Ontario Department of Agriculture

Sixty-Ninth Annual Report

of the

Entomological Society

of Ontario

1938

PRINTED BY ORDER OF

HON. P. M. DEWAN, Minister of Agriculture

ONTARIO

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1938

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Entomological Society of Ontario

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Auditors—PROF. L. CAESAR, Guelph; G. G. DUSTAN, Guelph.

FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31, 1938

Receipts		*Expenditures*	
Cash on hand	440.30	Printing, Canadian Entomologist	1170.00
Dues	292.58	Salaries	250.00
Subscriptions	496.70	Reprinting Can. Ents.	44.00
Advertisements	312.65	Postage	44.67
Government Grant	350.00	Stenographic Assistance	45.00
Back Numbers	71.67	Annual Meeting (1937)	24.95
Bank Interest	11.58	Bank Exchange	15.98
Life Membership	25.15	Miscellaneous	39.86
Miscellaneous	2.50	Cash on hand	.30
			1634.76
		Balance in Bank, 31 Oct., 1938	368.37
	2003.13		2003.13

Respectfully submitted,
REG. H. OZBURN,
Secretary-Treasurer.

Audited and found correct.

L. CAESAR,
G. G. DUSTAN, *Auditors.*

Entomological Society of Ontario

REPORT OF COUNCIL 1937-1938

The Council of the Entomological Society of Ontario begs to present its report for the year 1937-38.

The Seventy-fourth annual meeting of the Society was held at the Royal Ontario Museum, Toronto, on Thursday, and Friday, November 18th, and 19th, 1937.

The morning and afternoon sessions, held in the Theatre of the Museum, were largely devoted to the reading and discussion of thirty-eight papers, dealing with various fields of entomology. These sessions were well attended by approximately one hundred members of the Society and visitors interested in the subject.

On Thursday evening an entomological dinner was held in the dining room of the Walker House hotel. Mr. L. S. McLaine, president of the Society, acted as chairman. Following a few brief remarks by some visiting and Canadian entomologists, Dr. Parrott of the Geneva Agricultural Experiment Station, N.Y., gave a fascinating talk on his recent trip to Africa, illustrated by five reels of motion pictures in colour. The dinner was well attended and a decided success.

The Society held a summer meeting from June 27th to July 2nd at Ottawa in connection with the 102nd meeting of the American Association for the Advancement of Science. Three general sessions and a symposium were held under the auspices of the American Association of Economic Entomologists, Entomological Society of America and the Entomological Society of Ontario. Twenty-five papers were presented at these sessions, with an attendance of approximately 75 persons primarily interested in entomology. Following the sessions, two field trips were held, one to the Petawawa Forest Experiment Station, and one to the Mer Bleu. In general the meetings were a great success.

It is the sad duty of the council to record the death of Mr. F. C. Gilliat. Mr. Gilliat was for seven years a member of the Nova Scotia branch of the Society, later becoming a member of the parent body.

The Canadian Entomologist, the official organ of the Society, completed its 69th volume in December, 1937. This volume of 285 pages, illustrated by 17 full page plates and 21 figures, contained 63 original articles, 12 research notes, 12 book notices, and 9 sections on "News and Views", in addition to a number of obituary and other notices. These articles were contributed by 55 authors including writers in Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Alberta, British Columbia, and 13 of the United States.

A meeting of the council was held at the Ontario Agricultural College on November 23rd, 1938 in connection with the Seventy-fifth Anniversary meeting of the Society. Amongst the business transacted and reported upon, the following items are worthy of note:—

The index to the Society's reports from 1900 to 1937 has been prepared by Mr. C. E. Petch of the Entomological Laboratory, Hemmingford, Que., and submitted to the Department of Agriculture for the province of Ontario. It is hoped that this index will be available to the members in the spring of 1939.

The revised constitution of the Society was passed upon by the council and submitted to the annual meeting and adopted contingent on the approval of the Ontario Department of Agriculture.

The invitation of the new president, Dr. Georges Maheux, to hold the Seventy-sixth annual meeting at Quebec City was unanimously accepted. Owing to the uncertainty of travelling conditions in November, the meeting is to be held on Thursday, Friday and Saturday, the first week in November.

Dr. John Dearness and Dr. W. E. Saunders, the two oldest members of the Society were elected to Honorary Membership.

The following is the list of members, delegates and visitors attending the Seventy-fifth Anniversary meeting:—

LIST OF MEMBERS, DELEGATES AND VISITORS PRESENT

Name	Address
Armand, J E.	Guelph, Ont.
Armstrong, T.	Vineland, Ont.
Arnott, D. A.	Chatham, Ont.
Arnold, R. F.	Toronto, Ont.
Baker, A. D.	Ottawa, Ont.
Baker, A. W.	Guelph, Ont.
Baker, Mrs. Grace	Guelph, Ont.
Bai	Belleville, Ont.
Balch, R. E.	Fredericton, N. B.
Baldwin, W. J.	Guelph, Ont.
Banin, Rev. Father F. E.	Ottawa, Ont.
Barclay, J. N.	Belleville, Ont.
Beall, G.	Chatham, Ont.
Beaudoin, N. P.	Montreal, Que.
Beaulieu, A. H.	Quebec, Que.
Beaulne, J. W.	Quebec, Que.
Boyce, H. R.	Vineland, Ont.
Briand, C. J.	Belleville, Ont.
Brodie, J. A.	Toronto, Ont.
Bryce, P. I.	Vineland, Ont.
Brown, A. W. A.	Ottawa, Ont.
Brown, Jos.	Quebec, Que.
Brown, W. J.	Ottawa, Ont.
Burnham, Miss J. C.	Fredericton, N. B.
Caesar, L.	Guelph, Ont.
Cameron, D.	Ithaca, N.Y.
Cameron, N.	Montreal, Que.
Chapman, R. K.	Guelph, Ont.
Christie, G. I.	Guelph, Ont.
F.	Vancouver, B.C.
Cory, E. N.	Maryland, Md.
Crawford, H. G.	Ottawa, Ont.
Dairaulte, Lionel	Berhierville, Que.
Dearness, J.	London, Ont.
Detweiler, J. D.	London, Ont.
Driggers, B. F.	New Brunswick, N.J.
Dustan, A. G.	Ottawa, Ont.
Dustan, G. G.	Guelph, Ont.
Dymond, J. R.	Toronto, Ont.
Follwell, J. H.	Guelph, Ont.
Findlayson, L. R.	Belleville, Ont.
Fleming, H. S.	Ottawa, Ont.
Fontaine, R.	Guelph, Ont.
Fowler, W. A.	Toronto, Ont.
Gaiser, L. O.	Hamilton, Ont.
Garlick, W. G.	Vineland, Ont.
Garlick, Mrs. W. G.	Vineland, Ont.
Gibson, A.	Ottawa, Ont.
Gilbert, H. A.	Ottawa, Ont.
Goble, H.	Guelph, Ont.
Goble, Mrs. H.	Guelph, Ont.
Gooderham, C. B.	Ottawa, Ont.
Gorham, R. P.	Fredericton, N.B.
Graham, A. R.	Belleville, Ont.
Graham, K.	Vernon, B.C.
Gray, H. E.	Ottawa, Ont.
Green, Thelma	Belleville, Ont.
Gregory, F. W.	Niagara Falls, Ont.
Hall, A. R.	Toronto, Ont.
Hall, J. A.	Simcoe, Ont.
Hammond, G. H.	Ottawa, Ont.
Hadley, C. H.	Moorestown, N.J.
Harber, E. W.	Ottawa, Ont.
Heal, R. E.	New Brunswick, N.J.
Heming, W. E.	Ithaca, N.Y.
Hilton, C.	Guelph, Ont.
Howitt, J. E.	Guelph, Ont.
Huckett, H. C.	Riverhead, N.Y.
Hudson, F. J.	Windsor, Ont.
Ide, F. P.	Toronto, Ont.
James, H. G.	Belleville, Ont.
Jarvis, T. D.	Toronto, Ont.
Kennedy, C. H.	Columbus, Ohio
Kennedy, Irene	Guelph, Ont.
Lagloire, P.	Quebec, Que.
Lapp, W. R.	Windsor, Ont.
Leiby, R. W.	Ithaca, N.Y.
Leopold, Rev. Father	La Trappe, Que.
Lester, E. G.	Guelph, Ont.
Lincoln, C. G.	Ithaca, N.Y.
Maheux, Geo.	Quebec, Que.
Maltais, J. B.	Hemmingford, Que.
Matthewman, W. G.	Ottawa, Ont.
Maxwell, C.	Fredericton, N.B.
McLaine, L. S.	Ottawa, Ont.
McNally, A. G.	Guelph, Ont.
McNally, Mrs. A. G	Guelph, Ont.
Mead, A. R.	Ithaca, N.Y.
Melander, A. L.	New York, N.Y.
Monro, H. A. U.	Montreal, Que.
Morris, F. J. A.	Peterboro, Ont.
Morris, Mrs. F. J. A.	Peterboro, Ont.
Neil, C. A.	Windsor, Ont.
Ozburn, R. H.	Guelph, Ont.
Ozburn, Mrs. R. H.	Guelph, Ont.
Palm, Chas. E.	Ithaca, N.Y.
Parsons, H. H.	Toronto, Ont.
Pass, H. A.	Toronto, Ont.
Patterson, D. F.	Vineland , Ont.
Petch, C. E.	Hemmingford, Que.
Post, R. L.	Rochester, N.Y.
Reek, W. R.	Toronto, Ont.
Reeks, W. A.	Fredericton, N.B.
Richmond, E. A.	Pennsylvania State. Col.
Richmond, H. A. R.	Winnipeg, Man.
Ross, D. A.	Guelph, Ont.
Ross, W. A.	Vineland, Ont.
Ryan, W. St. G.	Montreal, Que.
Sands, D. R.	Guelph, Ont.
Seamans, H. L.	Lethbridge, Alta.
Seamans, Mrs. H. L.	Lethbridge, Alta.
Saunders, W. E.	London, Ont.
Schwardt, H. H.	Ithaca, N. Y.
Sheppard, R. W.	Niagara Falls, Ont.
Short, S. H.	Ottawa, Ont.
Simmons, S. A.	Guelph, Ont.
Smith, C. W.	Belleville, Ont.
Smith, J. M.	Guelph, Ont.
Stroud, J.	Hamilton, Ont.
Stevenson, L.	Guelph, Ont.
Stirrett, G.	Chatham, Ont.
Thompson, R. W.	Guelph, Ont.
Thompson, Mrs. R. W.	Guelph, Ont.
Troyer, S.	Toronto, Ont.
Troyer, H.	Toronto, Ont.
Twinn, C. R.	Ottawa, Ont.
Urquhart, F. A.	Toronto, Ont.
VanSteenburg, W. E.	Belleville, Ont.
Vroom, P. N.	Ottawa, Ont.
Walker, E. M.	Toronto, Ont.
Warren, A. E.	Hamilton, Ont.
Wilkes, A.	Toronto, Ont.
Wishart, G.	Belleville, Ont.
Wressell, H. B.	Toronto, Ont.

THE PROGRESS OF ECONOMIC ENTOMOLOGY IN ONTARIO SINCE THE ORGANIZATION OF OUR SOCIETY IN 1863

By L. Caesar

Ontario Agricultural College, Guelph

Any one who reads the early papers on entomology in Ontario will, I think, agree that up to the time of the organization of the Entomological Society of Ontario in 1863, very little progress had been made in economic entomology. The reason for this becomes evident when we find that entomology in those days consisted chiefly in the capturing, naming, and classifying of insects, in the study of their habits, and, in many cases, of their life histories. This was done, however, as a hobby without any monetary compensation. Insects were found to be intensely interesting creatures, and so the early entomologists studied them for their own sake, and not with the object of finding out how to destroy them. Many of us study birds for exactly the same reason. We should remember, too, that it was only their spare time that was devoted to entomology, for they all had other occupations by which they earned their livelihood.

Yet in spite of the above facts, there were always a few entomologists who realized the great damage being done by insects, felt sorry for those who suffered, and tried to think out how they could be helped. Among such men—two stand out preeminently—Dr. Saunders and Dr. Bethune. Being very public-spirited, they were eager to find out everything they could about injurious insects, and to give the public the benefit of their knowledge. I should not be surprised if this was the chief motive which influenced them in trying to bring about the organization of the Society in 1863. They, therefore, may be called the fathers of economic entomology, not only in Ontario, but also in Canada.

Up to about 1868 the public, and even the Department of Agriculture, did not realize that entomologists might, if given a chance and the necessary monetary support, be able to do a great deal for agriculture by finding out how to prevent insect ravages. Fortunately a chance to show their usefulness came soon after 1868 when the Colorado potato beetle arrived in Ontario. In a few years this great pest had spread all over the province and had increased to such an extent that the growing of potatoes seemed doomed. Hand picking and other methods failed as a control. A little while before 1870, the Department of Agriculture had begun to take some notice of the Society and had requested it to prepare for them a report on some of the more important insects of the province. Dr. Saunders, Dr. Bethune and Mr. Reid undertook this task. Dr. Bethune wrote on "insects attacking the apple", Dr. Saunders on "insects attacking the vine", and Mr. Reid on "plum insects". The first annual report of the Entomological Society contained the papers on these. So valuable were they considered by the Department that it now asked the Society to appoint a committee to investigate and report on the potato beetle. Dr. Saunders and Mr. Reid undertook this work, and the former, owing to his knowledge of chemistry, suggested that they try Paris green. This was done and, as you all know, proved effective. The excellent report on the potato beetle and the utilization of Paris green resulted in the Department's giving a grant of $1,000 to the Society, and in stating its readiness to publish annually the reports of the Society. This grant and the publishing of the annual report each year proved to be a great step forward, for it provided a means of recording any new discovery in Economic Entomology, and in making it easy for all students of the subject to get access to such knowledge. It was

also of advantage to fruit growers and others who were interested and whose welfare was affected.

Having now Paris green and some government support, the entomologists were able to make more rapid progress. They soon found that Paris green would control many other troublesome pests besides the potato beetle, such as the codling moth, plum curculio, currant worms, cabbage worms and cutworms. Paris green made the spraying of orchards for both insects and diseases really practicable, because Bordeaux mixture was already known, and thus for the first time a good insecticide and a good fungicide could be used together without the expense being excessive. Very fortunately too, Bordeaux mixture added to the Paris green helped to remove one of its greatest weaknesses, namely, the tendency to burn. It also helped Paris green to adhere better. Thus the entomologists, working in co-operation with the horticulturists and the botanists, had now got a fair start, and were making a noticeable contribution to the province.

After the discovery of Paris green, there was a long period in which entomologists, botanists and horticulturists were trying by demonstrations, bulletins, circulars and addresses, to educate the fruit growers to spray their orchards. One of the greatest troubles was that in the early days, spray machines were all small hand-power outfits. This made the work very slow and difficult to do well. It required as long a time for two men with the best of these outfits to spray well a single large tree as it does today for two men with a modern outfit to spray ten such trees. However, progress was being gradually made in spraying machinery.

In the meantime, Dr. Saunders in 1883 published his famous book on "Insects Injurious to Fruits". This was greatly sought, not only by all entomologists, but also by many progressive fruit growers, and was of great value, especially because the good illustrations and descriptions and the numerous insects discussed made it possible to identify almost any orchard insect, and also because the life histories of the insects were given along with suggestions on control. Entomologists owe a great deal to Dr. Saunders for the publication of this treatise, for in it the substance of almost everything that the entomologists in the United States as well as Canada knew about fruit insects of economic importance, was recorded.

The discovery in 1897 that the much dreaded San Jose scale had been imported into Canada and had already spread through many orchards in the Niagara district and in Kent county, once more produced a crisis. For several years it looked as if entomologists and horticulturists combined would not be able to save our fruit trees. It is said that over two million were killed. However, at last this insect turned out to be more of a blessing than a curse, for it lead to the discovery in the United States of lime sulphur as an insecticide. From the United States we too learned how to make it for our own use. From this discovery perhaps even greater benefits to the fruit growers followed than from the use of Paris green; for it was soon found that lime sulphur would control not only the San Jose scale but also the oyster shell scale and blister mite, two very great pests in those days, but perhaps as important as this, it was a very effective fungicide for nearly every serious fungus disease of the orchard—peach leaf curl, apple scab, brown rot of stone fruits, cherry leaf spot, and mildew on gooseberries. For some of these it was much better than Bordeaux mixture, and gradually superceded it to a large extent.

Lime sulphur, however, was found to be incompatible with Paris green. Hence from this fact and the knowledge that had gradually come to grow-

ers that Paris green tended to burn foliage, unless combined with Bordeaux mixture, and washed off quickly, it was seen after a few years that a new stomach insecticide was very desirable. Once more an imported insect in the United States—the gypsy moth—gave us this in the form of arsenate of lead. The splendid adhesive properties of this poison, its much greater safety to foliage, and its compatibility with almost all other spray mixtures, has been a great help to us in our work.

Since the discovery of arsenate of lead, most of the progress in insecticides cannot, I think, be attributed to the importation of new pests into Canada or the United States, though new pests such as the European corn borer and the Oriental peach moth have brought new responsibilities to the entomologists and spurred them on to greater efforts, which often led to better progress. At the same time, these insects have made it necessary for the government to grant more money to meet the emergencies and to increase the number of entomologists and improve their equipment, all of which, of course, has helped greatly.

The progress in insecticides since about 1900 should be attributed, I believe, very largely to our enlisting the co-operation of the chemists. Think of the benefits our profession has received from the chemists of the Bureau of Chemistry, Washington, D.C., and other chemists both in the United States and Canada through their extensive search for new insecticides. When mentioning chemists, we should not overlook the fact that the great insecticide companies have, for some years, been doing much by the use of their own chemists and entomologists to improve insecticides in general. I shall not try to deal with any of these new insecticides, however, other than to remind you that the discovery of fluorine compounds, especially sodium fluoride, and of derris, has been of great benefit, and that it has enabled us to get at last a satisfactory control for several of our worst household and domestic animal pests, such as cockroaches, lice on cattle and warble flies. Pyrethrum is of course not a new insecticide.

When thinking over the history of entomology in the last seventy-five years, I was impressed by the fact that the greatest cause of slow progress during the first half of the period could probably be attributed to the lack of leadership. Neither Dr. Saunders nor Dr. Bethune or any of the other men of those days could afford the time necessary for real leadership. Yet without a paid leader, who could give all or most of his time to the subject, there could be little good research carried on, no proper training of inspectors or local leaders, and no definite and reliable up-to-date source of information for the general public. Hence in the United States we find that as soon as Riley was appointed by the central government as the first real economic entomologist, and in Canada as soon as Fletcher was appointed to a similar position, these men quickly made a great change, brought order out of chaos, and, so to speak, put entomology soundly on its feet. Fletcher, like Riley, was a man of great ability and tireless energy, and I think probably did more for economic entomology in Ontario, or in fact in Canada, than any other man.

Fletcher's appointment was in 1884. About 1893 Prof. Panton of the Ontario Agricultural College began to give lectures on entomology to his students, and to help in extension and research work; one of the first things he did was to publish a little bulletin with instructions on spraying. Ever since then the professors and lecturers in entomology at this college have co-operated with the federal branch in giving leadership in addition to the contribution they have made through the teaching of entomology to

all students and the training of specialists. By far the greatest number of entomologists in Canada have I think received their training at the O.A.C.

This leads me to spend a little time on the question of educational facilities in the early days compared with today. The contrast is, of course, very great. Dr. Bethune, in one of the annual reports, described how difficult it was to get literature, and how he finally got a lot of his training by making the acquaintance of older men who helped him over many of his difficulties. The first course in Entomology, a very brief one of five lectures, was given as said above by Prof. Panton of the Ontario Agricultural College in 1893. Little by little, as the need for it became more evident, the course in this college was lengthened and improved. I need not go into details but will simply call your attention to the fact that there are good courses available today in entomology in several of the agricultural colleges and in most of the universities of Canada, that the literature on the subject is very extensive and accessable, and that there are excellent indices by which we can often find in a few minutes nearly everything that has been written on any particular insect or entomological topic anywhere in the world.

There are, of course, several other lines of progress which might be interesting to discuss, such as the progress being made in fumigants, in the study of forest insects, the greatly increased attention to the study of environmental factors and biological control, and the assistance of legislation, of quarantines, and embargoes. But we all know about these things for they are all receiving attention in almost every state and province. We all know, too, how entomology has broadened out to take in not only farm pests, but all kinds of insects.

In conclusion, I want to call attention to what has been perhaps the greatest factor of all in the progress of economic entomology in Ontario, that is, the presence of the United States of America along all our southern boundary. We owe more than we can ever express to our American friends. Most of us were brought up on Comstock's Manual. Thousands of times we have turned to Metcalf and Flint, or Herrick or Sanderson's great treatises. When we found an insect we could not get identified at home, we sent it to the specialists at Washington or other parts of the United States, and they were never too busy to name it. In a word ,they have practically put at our disposal all their vast fund of knowledge and told us to help ourselves. They have truly been "the good neighbour" to us. We are grateful for the help we have received and hope that we are gradually becoming able to return some of these favours.

With the United States and Canada working in close accord, and keeping in touch with the progress in other countries also, the future of entomology seems very bright and the contribution it will make to mankind will be exceedingly valuable.

We older entomologists would like to have a chance to see the changes that will have taken place in even twenty-five years, for they will probably be much greater than those of the last fifty.

THE HISTORY OF ENTOMOLOGY IN NOVA SCOTIA PARTICULARLY IN RESPECT TO THE ACTIVITIES OF PROVINCIAL AUTHORITIES

By A. D. PICKETT and H. G. PAYNE
College of Agriculture, Truro, N.S.

Previous to 1882 there appears to have been little attention paid to the study of insects in Nova Scotia except by a number of private individuals. About 1830 a Lieutenant Redmond (8) made a collection of Nova Scotia insects, mostly Diptera, which are housed in the British Museum. In 1864, Thomas Belt (1) collected Lepidoptera in the vicinity of Halifax. Between the years 1870 and 1879, J. Mathew Jones (8, 9) made a collection of Coleoptera, Hymenoptera and Lepidoptera in this province. In 1879, the Rev. C. J. S. Bethune (2) published a list of 79 species of Lepidoptera from Nova Scotia with notes by J. Mathew Jones, and Arthur P. Silver (12) in 1888 compiled a list of 46 species of Nova Scotian butterflies. It is thought this latter collection was made in the vicinity of Halifax. Andrew Downs (10) collected insects in the vicinity of Halifax in the late 1880's. Since 1900 more extensive collections have been made by numerous workers. Additional information on these may be obtained by reference to a paper by Brittain (4) in 1918.

In 1864 the legislature of Nova Scotia established a Central Board of Agriculture under the Act for Encouragement of Agriculture. This Board carried on the activities that under our modern system would come under the jurisdiction of the Department of Agriculture. It continued to function until 1885 when it was abolished and the work continued under the direction of the Governor-in-Council. It was during the period of the Board's activities that the first mention is made of governmental action in the control of insects. The following excerpt is taken from the report of the Board to the Provincial Secretary, 1882, p. XXXIV. "During last year the so-called Colorado or Potato Beetle, which has been so destructive to the potato crop in other parts of America, has begun to show itself in Nova Scotia. The Board has collected information as to the best means of destroying it, which will be diffused among the farmers at the proper season. Persons in whose neighborhood the insect may appear are invited to apply to members of the Board for circulars or advice".

It will be noted from the foregoing that the introduction into the province of an insect which threatened the destruction of an important food crop brought immediate action from a government board. The following quotation is taken from the Board's Report for 1883, p. 12. "As will be observed from statements in the Report of Societies (Agricultural Societies) the POTATO BEETLE appeared in several Counties. The Board at once mailed circulars to persons in the infected districts giving full instructions how to deal with the enemy. It is believed that vigilance on the part of potato growers in carrying out the instructions given will effectually prevent the spread of this pest to any serious extent in this Province".

From the above it would appear that government officials of those days had the same fond hopes as those cherished by many of their modern counterparts in thinking that the recommended control measures for pests would be carried out precisely. These appear to be the only references to insects in the reports of this Board during its twenty-one year tenure of office. As the Board reported on all matters dealing with agriculture, it is apparent that no severe outbreaks of insects occurred during this period.

It is probable that the first instruction in entomology was given in 1885. In that year Professor H. W. Smith, B.Sc. was appointed lecturer

in Agriculture at the Provincial Normal School in Truro. In 1888 a farm was purchased at the site where the Nova Scotia Agricultural College is now located. This was to be operated in connection with the School of Agriculture. In a report of the activities of the school for that year, Professor Smith specifically mentions entomology as one of the courses being taught. In that year twelve students were registered at the school. Instruction in this subject has not been discontinued since that date.

The 1889 Report of the Secretary for Agriculture describes methods of dissemination of the Colarado Beetle and warns farmers of the danger of importing destructive insects and disease along with grains and other plant products. Professor Smith in his report on the work of the School of Agriculture states that "Entomology is taught, without any apparatus whatever to use: This is an important branch in this Province. A little assistance here would be a great help." In his report for 1892 Professor Smith recommends the appointment of an entomologist, the following being an excerpt from his report: "There is need of a good entomologist for the province, who would devote his time and energy to the fruit growers and farmers of the province. Now, if he were employed as Professor of Entomology in the Provincial School, he could visit these local schools and experiment stations, and could have experiments conducted, and by so doing, show the farmers how to combat their numerous insect enemies, etc. At the same time he could give instruction in this line to the pupils of this local school." It may be of interest to remark here that it was just twenty years later that this recommendation was carried out. Further in Professor Smith's report for the same year, he gives information as to the prevalence and life histories of the cabbage maggot, wheat midge and wireworms, although most of the information appears to have been supplied by outside sources.

The report of the Secretary for Agriculture for 1894 carries a report on the finding of scale insects attacking plums, peaches and gooseberries. These were found at Dartmouth and Wolfville. In the report of the School of Agriculture for 1894 it is stated that a special course in entomology was given by Mr. C. E. Churchill.

In 1895 we find the first report of the Nova Scotia School of Horticulture. This school was established at Wolfville in 1893 and was operated under the direction of a Board appointed by the Nova Scotia Fruit Growers Association. A grant to assist in paying the operating expenses was provided by the Provincial Government. Professor E. E. Faville, B.Sc.A of Ames, Iowa was engaged to direct it. A course in economic entomology constituted a part of the prescribed studies. In 1898, Mr. F. C. Sears, M.S., a native of Massachusetts, and a graduate of the Kansas Agricultural College was appointed director of the School. In 1904 the school at Wolfville was discontinued and the work transferred to the College of Agriculture, Truro.

The report of the School of Agriculture for 1896 states that one of the problems on which students have carried out investigations is the life history of the cabbage butterfly and the outbreak of plant lice in Cape Breton. In the same year, Mr. I. S. Bishop of Auburn, N.S., in a report on cranberry culture makes note of the "ravages of the fire worm" an a large bog at Auburn, Kings County.

The report of the Director of the School of Horticulture for 1900 includes the results of experiments on the control of the forest tent caterpillar on apple by the use of Paris green. The report of the Principal of the School of Agriculture ,Truro, for the same year announced the erection of a new building to replace that destroyed by fire in 1898. The new building had special laboratories for the study of science subjects including entomology.

In December 1900, the junior author became associated with the work of the provincial government at the School of Agriculture, Truro. From that time up to the present he has been associated with the College and the Department of Agriculture in various capacities, and during the entire period has been interested in the collection and classification of insects. When the permanent insect collection was started in the new Science Building at the College in 1915, he gathered the old collections together and ever since has been largely responsible for its care and development. In addition he has built up an extensive private collection.

The report of the Secretary for Agriculture in 1901 records the employment of a special inspector, Professor W. C. Thro of Ithaca, N.Y. for the period of one month to inspect imported nursery stock for San Jose scale. He reports that the insect was not found in any of the orchards visited. In 1902, Professor Ruggles of Cornell University, Ithaca, N.Y. was engaged to inspect imported trees. No living San Jose scale was found at that time.

In 1905 Dr. M. Cumming was appointed principal of the Nova Scotia Agricultural College, Truro, and Professor H. W. Smith was appointed professor of biology. The college staff consisted of six full time men and they were assisted by members of the Provincial Normal School staff. This allowed more time for such science courses as entomology. In Professor Smith's report for 1906 he states that 1600 species of insects were collected and 600 of these mounted for student use.

In 1905 the first brown-tail moth adult was taken at Digby on July 14th. However, this finding was not recorded at the time. The presence of the insect in the province was first called to the attention of the authorities by C. Perry Foote of Lakeville, Kings County, in April 1907. The finding of this insect furnished the incentive to bring the importance of economic entomology to the attention of all concerned.

For the decade following its apearance extensive reports were given each year on this pest. The control work was undertaken at first by provincial authorities, but they were soon joined by officers of the Dominion Entomological and Fruit Branches and the work of eradication was carried on on a co-operative basis. At first a bounty was paid for the winter nests, but this was later substituted by spraying in infested areas and the gathering of winter nests by government officers. At this point it may be of interest to record that although as many as 24,156 of these nests were taken in the winter of 1913-14, it gradually decreased until the winter of 1926-27 which was the last year in which winter nests were taken. Further details may be found in the report of Gilliatt (7) in 1920

In 1911 the "Injurious Insect Pest and Plant Disease Act" was passed by the provincial legislature and in July of the same year Regulations were passed under this Act empowering the Secretary for Agriculture to order treatment of, or destruction of, infested vegetation and the following insects were declared subject to the Act: San Jose scale, brown tail moth, gypsy moth and woolly aphis. In his report for the same year the Secretary for Agriculture urged the establishment of a laboratory by the Dominion Department of Agriculture in the Annapolis Valley for the study of the brown tail moth and other insects.

In October, 1912, Dr. Robert Matheson was appointed Provincial Entomologist and Professor of Zoology at the Nova Scotia Agricultural College, Truro. It is believed that he was the first provincial entomologist to be appointed in any province of Canada. Probably the incentive respon-

sible for this appointment was the finding of San Jose scale at Aylesford, Kings County, on nursery stock earlier in the year. We find his first report to the Secretary for Agriculture in this same year. This is concerned almost entirely with the work undertaken to control the San Jose scale and brown tail moth. In October 1913, Dr. Matheson resigned and W. H. Brittain was appointed to succeed him. In this year we have the first official record of the occurrence of the apple maggot in the province. In the report of the Provincial Entomologist for 1914, is found an account of the establishment of a provincial field laboratory at Kentville; C. A. Good was appointed Assistant Entomologist and placed in charge. In the same year fumigation stations were built at Truro, and Digby. Also in this year the Science Building at the Agricultural College was constructed. This provided spacious offices, laboratories and a class room for the accommodation of the Entomological Division.

The equipment of these laboratories has been gradually improved and it is now one of the best equipped divisions in the College. During the decade following the appointment of a provincial entomologist, the work of this division developed rapidly. A permanent insect collection was started and has gradually been enlarged until to-day it is probably the most extensive to be found in the Maritime Provinces. Under the energetic direction of W. H. Brittain investigations on the control of many important insect pests were undertaken. These have been of inestimable benefit to the farmers of Nova Scotia as well as to the neighboring provinces. A considerable number of scientific papers and bulletins were prepared and published as well as numerous publications of a popular and practical nature, the enumeration of which would be too extensive to be included here.

In 1915 an entomological field laboratory was opened at Smith's Cove, Digby County in order to study the apple maggot. A report of these investigations was issued by Brittain and Good (6) in 1917.

In the same year a bulletin on the green apple bug, *Lygus communis* Knight, was issued by W. H. Brittain (3) and in 1923 the same author published an account of extensive studies on the European apple sucker, *Psyllia mali* Schmidberger (5). This insect was first found on this continent at Wolfville in 1919.

There was little change in the manner in which the entomological work was carried on until 1926. In that year Dr. Brittain severed his connection with the College of Agriculture and became Professor of Entomology at Macdonald College, McGill University. He continued to hold the position of Provincial Entomologist for three years, spending the summers in a study of fruit insects in the Annapolis Valley. During this period the teaching of entomology at the College was carried on by A. R. Prince, a general biologist.

In 1928 the senior author was appointed Assistant Provincial Entomologist and in 1929 he was promoted to the position of Provincial Entomologist following the resignation of Dr. Brittain from that position.

The development of entomological work during the past decade has been largely along the line of the establishment of a comprehensive spray service involving practically the whole of the fruit growing areas of the Annapolis Valley. This development has been carried on in cooperation with the Extension Division of the Nova Scotia Department of Agriculture.

In 1938 there were over one thousand fruit growers taking advantage of this service. In 1938 what is believed to be a new departure in agricul-

ture extension work in Canada has been undertaken by the Entomological Division, working in conjunction with the Extension Division. This involves the establishment of a scheme of orchard supervision by officers of the division. Contracts are drawn between the Department of Agriculture and certain fruit companies on behalf of their members. The acceptance of the scheme is voluntary on the part of the fruit grower, but he agrees to carry out the directions of the department official. The fruit company involved reimburses the Department on behalf of its member growers who participate in the scheme. The charge made is on a barrelage basis. The first years' results have been reasonably satisfactory.

Other activities include special studies on the apple maggot, *Rhagoletis pomonella* (Walsh), and its "forms" found on various host plants. A report on this work by the senior author (11) has been published. Also, the Entomology Division has been active in promoting and carrying out a compulsory program of control for this insect, first on its own authority and later in cooperation with the Provincial Apple Maggot Control Board. It has been the policy of the Division to prepare each autumn a forecast of the probable prevalence of fruit insects for the following year. These forecasts have been so well received by the fruit growers that it has been an accepted practise to base seasonal spray programs on them. Other activities of the Division are too numerous to enumerate here.

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HISTORICAL NOTES ON THE DEVELOPMENT OF ENTOMOLOGY IN QUEBEC

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The notes I am going to present regarding the development of entomology in Quebec are far from being complete. I know that Mr. Munro, who is a keen student of history, has prepared a review of the early literature in which he has gathered notes of entomological interest. In this paper I wish to deal very briefly with applied entomology.

The beginnings of applied entomology in Quebec are not easily determined. It is very likely that the first real evidence dates back to the days of Provencher. Credit must be given to l'abbe Leon Provencher for his many publications in the field of the natural sciences and especially in entomology. I believe that the first booklet on injurious insects was published in Montreal in 1857. It was entitled "*Un essai sur les insectes et les maladies qui affectent le ble.*" (*An Essay on the Insects and Diseases Affecting Wheat*). The author, Emilien Dupont, is but a "nom de plume" for l'abbe Leon Provencher. This essay received third prize in a contest organized by the Department of Agriculture and Statistics of the United Canadas. H. J. Hind, professor of chemistry at Trinity College, Toronto, won first prize and Rev. George Hill, of Markham, won second prize.

In this essay, Provencher enumerates 8 insects injurious to wheat, namely: white grubs (*Melolontha vulgaris*), wheat weevil (*Calendra granaria*), *Saperda gracilis* (unknown here, but mentioned by French authors under the name *Agapanthia marginella*), grasshoppers, the flour moth (*Tinea granella*), the Hessian fly (*Cecidomia destructor*). the wheat fly (*Cecidomyia tritici*), and the angoumois grain moth.

There are some interesting personal observations regarding four of these insects, but some others have been directly transposed from French works. A few years later, in 1862, Provencher published the first edition of his "*Verger Canadien*" (Canadian Orchard) which was followed two years after by "*Le Potager Canadien*" (The Canadian vegetable garden). In 1874, he published in one volume the revised text of these two booklets. There are in all about 18 pages dealing with injurious insects and their control. Fruit insects are fairly well treated, but there is absolutely nothing on vegetable insects. During this period, Provencher became exclusively interested in systematic entomology and even in "Le Naturaliste Canadien" there is not much material regarding economic entomology.

Except for occasional mention of noxious insects in agricultural text books, absolutely nothing was published in French from 1874 up to the end of the last century. A few workers, such as Beaulieu, Chagnon, Huard and others, tried to keep up the interest in entomology that had marked the period of Provencher. There were collectors who started to build up collections in different parts of the province. The entomological collection of Laval University was built up by William Cooper, F. X. Belanger, J. Morrisson and C. E. Dionne. William Cooper seems to have been very active as many articles written by him have been published in the Transactions of the Quebec Literary and Historical Society.

The real development of economic entomology is certainly due to the application of the Agricultural Instruction Act. Following this Act part of the annual subsidy was reserved to horticulture and entomology. In 1914, the first provincial entomologist was appointed and in the same year the first Plant Protection Act was also passed by the Legislative Assembly. The details of this last period are fairly well known. Briefly summarized they are the teaching of entomology as a special course in agricultural and forestry schools; the development of the Division of Entomology which is now a part of the Plant Protection Service; the publication of the Reports of the Plant Protection Society, and a few books, namely: Lockhead's, *Economic Entomology;* Beaulieu and Maheux's, *Injurious Insects of Quebec;* Daviault's, *Entomological Fauna of the Betulacae;* and Chagnon's, *Coleoptera of Quebec;* without mentioning the numerous extension bulletins, circulars, calendars and posters published by the Department of Agriculture and Agricultural Schools.

The Quebec Society for the Protection of Plants, founded in 1908, has rendered great services to the cause of entomology. The first Dominion Entomological Laboratory in Quebec was opened at Hemmingford in 1912 and has always been under the capable direction of Mr. C. E. Petch. A new chapter is now being written in economic entomology by those who study forest insects. Laboratories at Berthierville, Laniel, under the Dominion Division of Entomology and the new provincial laboratory at Duchesnay, mark a new step in the advancement of applied entomology. Everything points to the rapid growth of these institutions for the next decade.

It is worthwhile mentioning here the magnificent response received from farmers in general and fruit and vegetable growers in particular. The great majority of these people are now "insect conscious" and they make every effort to adequately protect their crops. The Spray Service, inaugurated in 1929, has been responsible for much of the success achieved in our fight against several injurious insect species. During the past summer experiments were conducted on many of the worst pests, either by the Dominion officers at their laboratory or by provincial officials at 4 summer stations. The successes in the fight against such large outbreaks as armyworms and grasshoppers reflects great credit on those in charge of the work, and, at the same time, serve to measure the progress made during the last 20 years. There is still much room for further achievement and we are just beginning to accomplish what should be done and what must be done in the field of applied entomology.

We have every hope of marked improvement in the next few years, because:

(1) Insect damage is responsible for losses that farmers in general want to eliminate; a large proportion of the growers have procured the necessary equipment.

(2) Important insect outbreaks have caused the authorities to be more sympathetic to entomologists and their work.

(3) Organized growers request technical direction for adequate crop protection.

(4) Experimentation is even requested by growers.

(5) From simple curiosities, entomologists have slowly become acceptable, useful people; their advice is now in demand.

(6) The progress in plant protection work has been far more rapid than in most other fields of agriculture.

STATUS OF THE JAPANESE BEETLE IN THE OLDER AREA OF INFESTATION

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The Japanese beetle (*Popillia japonica* Newn.) continues to be an insect of great interest to many people. Those living in areas that have not yet been reached by the insect are espcially interested in its development and present status in the area in which it has been longest established.

It is fair to assume that the changes undergone by the beetle in this area after a relatively long period of establishment have brought about a condition approaching relative stability in the adjustment of the insect to its present environment, and that this condition may, within reasonable limits, be taken as somewhat indicative of what may be anticipated in any other area in which the insect may become established where environmental and other conditions are comparable. It is, then, the purpose of this paper to review rather briefly the changes that have taken place in the oldest area of infestation and to consider the present status of the insect.

For the purposes of the present discussion, the writer's remarks will apply only to that part of the earliest infested area within a radial distance of approximately 40 to 50 miles from Philadelphia, Pa. Within this area the beetle has now been present and more or less abundant for a period of 10 to 15 years. Here the beetle has found conditions ideally suited to its rapid multiplication; an abundance of its favorite food plants, exceedingly favorable climatic conditions, and few native insect parasites to hinder its development.

Life History.—In the area under consideration, the life cycle of the Japanese beetle is completed in a single year, most of the time being spent in the ground as grubs or larvae. As winter approaches the larvae move downward and enter hibernation at depths of from two to five inches below the surface of the ground. In the spring the larvae again become active, moving up close to the surface late in March or early in April to resume feeding. After passing through a short pupal stage, emergence of the beetles starts, generally between the 15th and 20th of June, and by the 5th of July is well under way. Mating of the sexes occurs soon after emergence and is repeated at frequent intervals throughout the summer. Egg-laying begins shortly after emergence and continues until the middle of August, by which time each female will have laid a total of from 40 to 60 eggs. The beetles feed voraciously throughout the summer, especially on warm, sunny, humid days, the peak of the feeding season generally occurring during the latter half of July. From the middle of August onward the beetle population diminishes and by the middle of September beetles are generally rather scarce. Eggs are for the most part laid in turf, and hatch in about two week's time. Larval growth during the summer and early in the fall is rapid, the larvae usually having reached the third or final instar by the time low temperatures inhibit further growth.

Feeding Habits and Food Plants.—The injury caused by the feeding of the adult beetle upon foliage and fruit is most conspicuous. Feeding is confined chiefly to the foliage on the upper and outer parts of plants exposed to bright sunlight and occurs during the warmer part of the day. On cloudy or cool days there is almost no feeding. The beetles consume the tissue between the veins of the leaves, causing the leaves to become wholly or partly skeletonized. Leaves

which have been thus attacked soon turn brown and fall, and as a result preferred food plants in heavily infested areas are often entirely stripped of their foliage. When the infestation is very severe even large fruit and shade trees may be completely defoliated within a few days. The beetles feed on a large number of trees and plants, but most of the injury is confined to a relatively limited number of the more favored species. The shade trees especially susceptible to attack are elm, horsechestnut, linden, Lombardy poplar, Norway maple, pin oak, and willow. The beetle also feeds on most of the common fruits. The foliage of apple, peach, plum, cherry, raspberry, blueberry, and grape is very often attacked but injury to the fruits occurs largely on the early-ripening varieties of apple, peach, plum, and grape. Ornamentals such as the flowering varieties of cherry and quince, althea, rose, and hollyhock are frequently severely attacked, and feeding is also common on dahlias, zinnias, and woodbine. Among the field and garden crops subject to attack under conditions of heavy infestation are asparagus, beans, field and sweet corn, rhubarb, and soybeans. Feeding on weeds is quite general, especially on mallow and smartweed.

The larvae or grubs of the Japanese beetle also frequently cause severe injury to plants by their feeding on the roots. Turf in lawns, golf courses, parks and pastures is most often attacked. Where turf injury is extensive the aerial portion of the grass is often completely severed from the roots by the larvae, causing the grass to die out in small patches or larger areas; the injured turf can easily be rolled back by the fingers much as a mat or rug is rolled up. Larval injury sometimes occurs on various truck and field crops, and has been especially common on newly set strawberries.

Beetle Abundance.—In the area under consideration there has been considerable change during the years in the relative abundance of the beetles. In the early years of the infestation, the beetle population built up rapidly to a high peak. In the peak period beetles were present in tremendous numbers. It was not uncommon at that time for a single beetle trap to catch 40 to 50 quarts of beetles in a single day, and a larval density of 1,500 or more grubs to a measured square yard was encountered not infrequently. At this time, feeding damage by beetles to favored food plants and by larvae on turf was very severe. This period of peak abundance lasted in general for from three to five years. For a period of several years thereafter the beetle population diminished noticeably each season, with a comparable decline in feeding injury. The low point in the beetle population lasted for several years. At the present time, throughout much of the area under consideration, there is evidence that the beetle population is somewhat on the increase, although it has not as yet reached anywhere near the peak condition of previous years. It must be understood, of course, that throughout the area under consideration there are a number of factors which influence the development and abundance of the beetle, and as a result much variation in the relative density of the beetle population occurs.

Factors Influencing Beetle Populations.—There are several known factors which appear to influence very materially the population density of the Japanese beetle. Climatic conditions unquestionably are a most important factor governing population changes. The application of artificial control measures has had a bearing upon the population density of the insect, especially at localized points where control practices have been generally used. The influence of such natural control agencies as the imported insect parasites and the soil-inhabiting microorganisms parasitic on beetle larvae are likewise important factors in the situation.

Studies have shown that the amount and distribution of the rainfall prior to and during the critical egg-laying and early larval periods of the

insect are most important limiting factors. In the area under consideration, this period is substantially the summer months, June, July, and August. The normal rainfall for these three months amounts to about 12 inches. Seasons during which the rainfall has been substantially less than this amount, or in which relatively long periods of drought have occurred, have been followed by a reduced beetle population the next year. For several years past, throughout much of this area, the summer rainfall during these critical months was substantially less than normal, and this condition has undoubtedly contributed materially to the reduction in the beetle population generally experienced over this area. The summer of 1938, on the other hand, was much more favorable for the beetle in that there was an abundance of rainfall during the critical months, and this was so distributed that soil-moisture conditions were practically ideal for the survival of eggs and small larvae. As a result, at the present time, generally speaking, there are noticeably more larvae in the soil as compared with larval populations for the same periods in the past several years.

Systematic soil surveys over a period of many years have shown that in this area normally but very few hibernating larvae are killed by low temperatures during the winter months. It is only in rare instances that the temperature of the soil at the depth larvae occur goes much below freezing.

Application of Artificial Control Measures.—Throughout this area the density of the beetle population has varied seasonally, and the need for the application of direct control measures against the beetle has varied in like manner. Under conditions of light to moderate beetle abundance, there is usually little need for the application of control measures directed primarily at the beetle for the protection of shade trees and commercial orchards; the control practices customarily followed for protection against foliage-eating insects usually provide adequate protection. Under conditions of heavy beetle infestation, however, such measures frequently fail to give sufficient protection, and additional measures are necessary. Under such conditions the control treatments recommended* have been generally used with satisfactory results.

The treatment of turf has been very generally adopted throughout the area, particularly in parks, cemeteries, golf courses, and lawns, as larval injury to turf frequently occurs even under conditions of moderate infestation.

While it is not practical to attempt to evaluate the permanent benefit of such control efforts, these have had a beneficial effect at least locally in the lessening or prevention of injury and have contributed in some degree to the reduction in the insect population of the immediate vicinity. Furthermore, it is the writer's opinion that the efficiency of commercial spraying operations in this area has been markedly improved owing to the necessity for greater care in spraying technique to obtain adequate protection during periods of maximum beetle abundance.

Importance of Natural Control Agencies.—Natural control agencies have unquestionably played a considerable part in the reduction of the insect population from that of the high peak of several years ago. No native insect parasites of any consequence have yet been observed attacking the Japanese beetle, but some of the imported

*U.S. Dept. Agr. Circular 237, Control of the Japanese Beetle on Fruit and Shade Trees, By W. E. Fleming and F. W. Metzger, 12 pp., illus., rev. 1936.

U.S. Dept. Agr. Circular 401, Control of the Japenese Beetle and its Grub in Home Yards. By W. E. Fleming and F. W. Metzger, 15 pp., illus. 1936.

U.S. Dept. Agr. Circular 403, Preventing Injury from Japanese and Asiatic Beetle Larvae to Turf in Parks and Other Large Areas. By W. E. Fleming 12 pp., illus. 1936.

parasites that have been released by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture have progressed in a very satisfactory manner. To date 1,804 colonies of two species of *Tiphia,* namely *Tiphia vernalis* and *popilliavora,* have been released within this and immediately adjacent areas.

As stated, both these species have developed in a very satisfactory manner, surveys at certain of the oldest colonies having shown a range of actual parasitization by *Tiphia vernalis* of from 30 per cent. where the host grub population averaged about one beetle larva per square foot to 60 per cent. in areas where the grub population averaged five per square foot. Of course the efficiency of all the colonies does not approach these figures, since the majority of the colonies have not been established long enough to develop to this degree; nevertheless, the evidence to date strongly supports the belief that these parasites are now beginning to be a factor in the situation and will doubtless become more important in future years.

Several other species of imported parasites have been released, but as yet these have not developed to anywhere near as promising a degree as the two species mentioned.

Among the more important agencies of natural or biological control of the Japanese beetle are certain pathogenic soil microorganisms, in the form of bacteria, fungi, and nematodes, which attack the larvae. In the fungus group, the most important disease is caused by the green muscadine fungus, *Metarrhizium anisopliae.* Several distinct species of parasitic nematodes belonging to the genus *Neoaplectana* have been encountered in relatively large numbers. Of the bacterial diseases, the most important are two milky diseases, so called from the white or milky appearance of infected larvae resulting from the development of spores of the causal organism in the blood of the host. These have been designated type A and type B milky diseases. Type A milky disease is by far the most important. Over 85 per cent. of all diseased larvae encountered in the field have been attacked by this type.

Type A milky disease and the fungus diseases have been found rather generally distributed throughout the older infested area, whereas type B milky disease and the nematode diseases are of less general occurrence. The incidence of these diseases varies seasonally and is influenced mainly by larval abundance, soil temperature, and soil moisture. The studies to date have shown that a tremendous build-up of disease follows the increase in larval population subsequent to its establishment in an area, and tends to reduce the normal peak of emergence which would otherwise occur if the milky diseases were not present.

Summary.—In the older area infested by the Japanese beetle the early epidemic period of maximum beetle abundance and destructiveness had been followed by a definite decline in beetle population and injury. This decline has been due in all probability to a number of factors:—the natural subsidence after epidemic conditions, due to the increasing effectiveness of natural agencies of control such as parasites and pathogenic soil organisms; the normal sequence of climatic conditions favorable and unfavorable to the insect; the adoption and continued application of improved methods of direct control; and other less evident but probably important causes. It may with reason be said that the insect is now approaching the status of a native pest in this area. Periods of relative abundance of the insect may be expected to be followed by periods of scarcity ,with varying degrees of destructiveness to vegetation. However, because of its wide range of food plants, its reproductive capacity, and its resistance to relatively unfavorable environmental conditions it is likely that it will remain a pest requiring the continued exercise of control efforts to protect favored food plants from economic damage.

RECENT EXTENSIONS OF THE KNOWN DISTRIBUTION OF THE EUROPEAN SPRUCE SAWFLY

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Since its discovery in the Gaspe peninsula in Quebec in 1930, the European spruce sawfly (*Diprion polytomum* Htg.) has steadily extended in its known range farther into the centre of the Dominion. Primarily in order to investigate this extent of distribution, the Forest Insect Survey was inaugurated in 1935 and commenced organized work in 1936. This paper covers the period from 1935 to 1938, when the major extensions of distribution were discovered by the junior author while scouting in connection with this project.

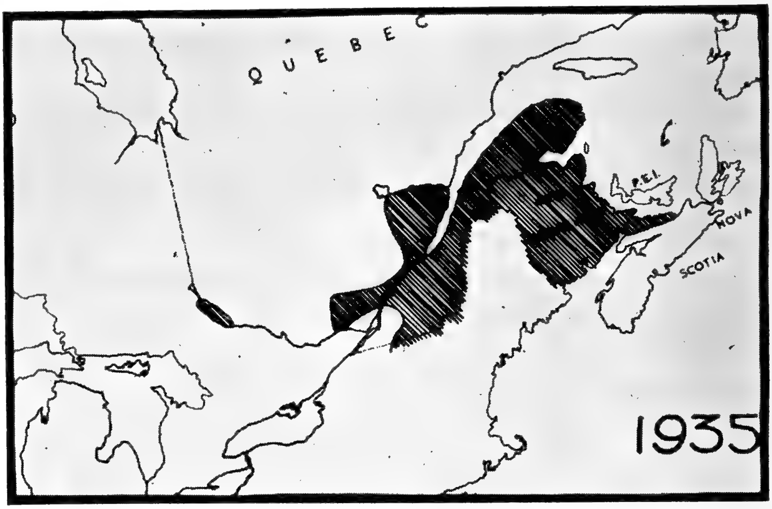

Fig. 1.—Known distribution of European Spruce Sawfly in 1935.

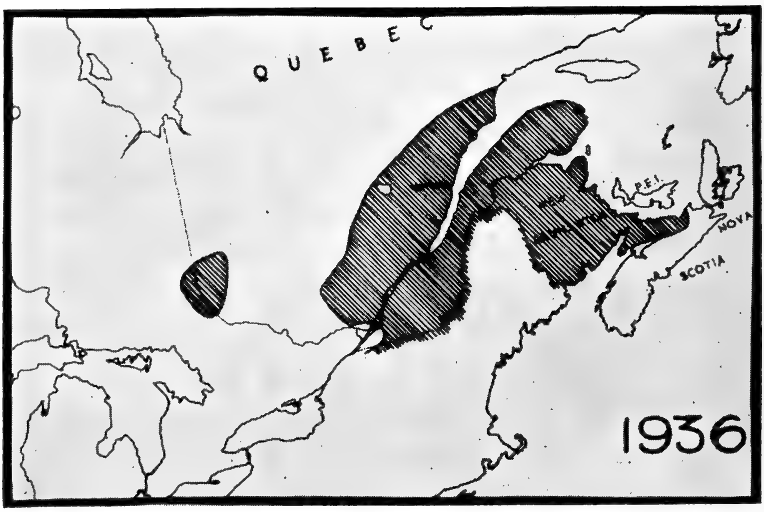

Fig. 2.—Known distribution of European Spruce Sawfly in 1936

Figure 1, taken from a plate in the report of R. E. Balch for the sawfly in 1935, summarizes the position in that year. Known distribution north of the St. Lawrence just reaches Lake St. John and the south bank of the Saguenay River, while surprising isolated records have been obtained on either side of Lake Temiskaming.

Building upon this basis, more complete information was obtained in 1936. (Fig. 2) The known distribution has been extended 200 miles down the North Shore as far as the Pentecost River. The boundary completely encloses Lake St. John and the lower St. Maurice Valley, to meet the established boundary in the St. Jovite area. The Temiskaming records have grown into an infestation area extending 25 miles into Ontario and 70 miles northeastwards into Quebec. Fairly good scouting in the intervening region failed to yield any records of the sawfly between the Temiskaming and the main infestations. It was, therefore, thought possible that this gap might be bridged along the northern transcontinental railroad.

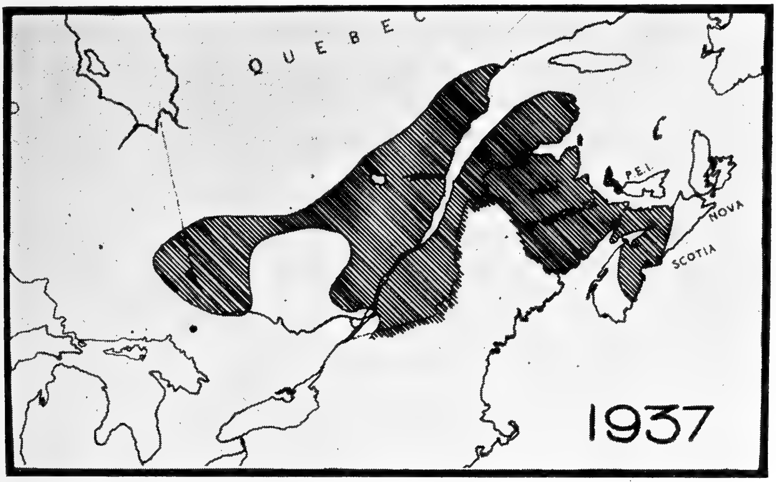

Fig. 3.—Known distribution of European Spruce Sawfly in 1937.

The results of 1937 (Fig. 3) confirmed this idea. Records at Forsythe, Oskelaneo and other points closed the gap; but the Gatineau-Lievre region in spite of quite extensive scouting still failed to show any sign of the sawfly. The Temiskaming infestation was found to extend northwards to reach Lake Abitibi, northwestwards into the Matachewan area of Ontario, and eastwards to Grand Lake Victoria. An outlying sample was received from Loring, south of Lake Nipissing (a thorough check of this area in the following year failed to reveal further specimens). In the Maritime region, the sawfly was found in western Prince Edward Island, and records for Halifax and Liverpool extended it well into Nova Scotia. This year witnessed a striking increase in population density in all areas.

Further advances of knowledge were made in 1938 (Fig. 4) An infestation of moderate intensity was discovered in southern Ontario. This area, 200 miles wide, extends as far southwest as London as far east as a short distance beyond Peterborough. The sawfly was also discovered in eastern Ontario, and scouting extended the boundary of the main infestation from Quebec to a line from Ottawa to Cornwall. No sawfly could be found in the intervening area; spruce is very scarce in the Kingston district.

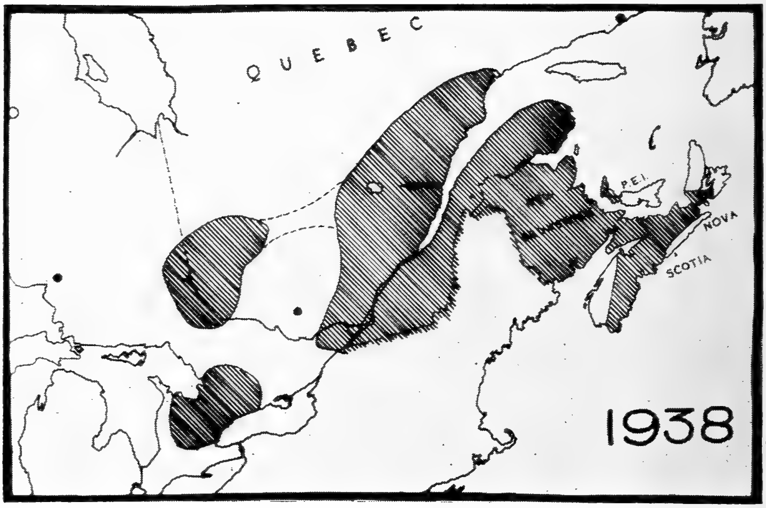

Fig. 4.—Known distribution of European Spruce Sawfly in 1938.

The boundary of the Temiskaming infestation has receded a little from the position of 1937, and no records were obtained in the "northern bridge", indicated in the figure in dotted lines. Very extensive scouting in the Gatineau-Lievre region yielded but one doubtful specimen, which is plotted at Gracefield. However, the Entomological Service of the Quebec Department of Lands and Forests reported three records in this area. An isolated sample was received from Petit Musquarro on the North Shore and another from Hawk Junction, Algoma. The latter record, being so important, was immediately followed up by an intense search in the area, which was unrewarded. In Nova Scotia, the infestation was found to include nearly all of the west of the province, and extended throughout the southern part of Cape Breton Island. The year 1938 witnessed a reduction in population density in nearly all regions, and a recession in known distribution in a few localities.

In conclusion, one must be prepared now to face the fact that the European spruce sawfly is present on all sides of Lake Ontario, and its western boundary extends northward therefrom at least up to the boundary of commercial spruce. Within this region, there is a Y-shaped area of such light infestation that larvae are very seldom found. The significance of the Hawk Junction record is doubtful, the district separating it from the main infestation, lying in the Sudbury inspectorates, having been thoroughly scouted with negative results for three years.

As to whether the foregoing results are due to extension of knowledge or to an actual extension of the sawfly, the authors are inclined to believe in a combination of the two factors, the extension of knowledge predominating.

Reference

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NATIVE INSECT PARASITES AND PREDATORS ATTACKING *DIPRION POLYTOMUM* (HARTIG) IN CANADA

By W. A. Reeks

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One of the reasons that the spruce sawfly, *Diprion polytomum* (Hartig), is considered to be an introduction from Europe is that parasites native to Canada have not attacked it in any great numbers. (2) In this connection it was thought to be worth while indicating the records of parasitism that have been obtained in Canada, thus giving some idea of the degree of freedom from parasites, and also presenting some notes on those native species of parasites and predators which have succeeded in attacking this sawfly.

Extensive studies by the Dominion Entomological Laboratory at Fredericton since 1931 have involved the collection and rearing of several million cocoons. As most of the cocoons were submitted to conditions making them unsatisfactory for an accurate estimate of parasitism, figures can only be quoted for a part, as follows: of 266,400 cocoons and larvae collected in the field and reared between 1931-1937, inclusive, 47 produced parasites.

Additional records have also been secured by the Forest Insect Survey and have been kindly provided by A. W. A. Brown of the Division of Entomology in Ottawa. Co-operating with the survey, the forest services and various companies have sent in nearly ten thousand samples of forest insect populations on spruce to the Ottawa and Fredericton laboratories. In 1936 and 1937 the Ottawa laboratory reared 9,188 cocoons and in 1937 the survey staff at Fredericton reared 25,554 spruce sawfly larvae collected at numerous points scattered throughout Eastern Canada. These collections have yielded seven specimens of native parasites.

Through the combined activities of the Fredericton Entomological Laboratory and the Forest Insect Survey, we have reared, up to 1937 inclusive, some 301,142 cocoons and larvae collected in the field. Only 54 produced native parasites, a percentage of .018. Ten parasites were also reared by the survey in 1938 but these are not included in the total indicated above as records for 1938 are not complete at the time of writing. All of our specimens of native parasites have not been identified, but at least 20 species have been reared from our sawfly collections.

Insect predators are of greater importance but do not appear to be a major factor in control.

The following is a list of those native parasites and predators of which we have records of successful rearing on *Diprion polytomum* in Canada. Determinations were made by specialists, including R. A. Cushman, W. J. Brown, G. S. Walley, C. W. Smith and G. Shewell.

PARASITES

Order *Diptera*

Family Phoridae

Megaselida sp. (near *probosidea* Mall).

One specimen was reared by the Forest Insect Survey from larvae sent in from Ste. Anne des Monts, P.Q. The adult emerged on August 10, 1937, in the Ottawa insectary.

Family Tachinidae

Bessa selecta Mg. This species is considered by some to be an introduced parasite, though it was present many years before imported parasites of *D. polytomum* were first released in Canada. It is an important parasite of *Pristiphora erichsonii* (Hartig) in New Brunswick and its eggs are

often seen on spruce sawfly larvae, particularly in central New Brunswick and less frequently in northern New Brunswick and Quebec. In 1938, *B. selecta* eggs were most numerous on this sawfly at the Acadian Forest Experimental Station, York County, N.B., where M. L. Prebble found that 3.6 per cent. of all the larvae collected periodically during the season bore eggs of the tachinid. Eggs were first observed on June 27 and appeared as late as November 5. One egg occurred on a second stage larva, three on third stage, eight on fourth stage, and one hundred and two on fifth stage larvae. This, however, does not represent the degree of successful parasitism as the majority of *B. selecta* eggs are cast off with the exuviae of the host larvae. In one experiment in which 42 fifth stage *Diprion polytomum* larvae were parasitized by *B. selecta,* all of the eggs were moulted off. Another collection from the Acadian Forest Experiment Station, consisting of 780 cocoons collected in May, 1938, produced four *B. selecta* adults and 12 puparia. This represents successful parasitism of 2.1 per cent., which is the highest record of parasitism attained by any native species. Other specimens reared at the Fredericton laboratory have been obtained from the following collections: 13 from 696 cocoons collected in 1934 at McNamee, N.B.; four from 284 cocoons collected in 1934 at Canaan River, N.B.; six from 2122 cocoons collected in 1937 at Kingsley, N.B.; and one from 2192 cocoons collected in 1936 at Parke Reserve, Kamouraska County, P.Q. Additional records from the Forest Insect Survey are as follows: one from Northumberland County, N.B.; one from Westmorland County, N.B.; one from Queens County, N.B.; one from Mechanic Settlement, Kings County, N.B.; one from St. Urbain, P.Q.; one from Outardes, P.Q.; one from Franquelin, P.Q.; and one from Windigo, P.Q. In 1937, first generation adults reared from larch sawfly cocoons collected in southern New Brunswick emerged early in June; 59 per cent. of the next generation emerged from July 21 to September 10, 1937, the remainder staying in diapause until 1938. The heavy infestations of the larch sawfly in New Brunswick during the last few years are probably the source of the *B. selecta* eggs so frequently seen on *D. polytomum* larvae. Puparia of *B. selecta* are sometimes formed inside the host cocoon, but more frequently the larvae leave the host cocoons to pupate in moss or ground litter.

B. selecta will also attack larvae of *Pikonema dimmockii* (Cress.) in cages.

Phorocera sp. (near *claripennis* Macq.). One adult was reared by C. E. Atwood from 20 cocoons collected in 1934 at Salmon River, N.B.

Phorocera hamata A. & W. One specimen emerged on August 11, 1938, from 485 cocoons reared by the Forest Insect Survey from several larval collections taken in Queens County, N.B.

Phorocera sp. (near *specularis*). This is a larval parasite, one of which was reared by C. E. Atwood from 16 larvae collected near Fredericton, N.B., in 1934.

Spathimeigenia aurifrons Carr. This is a common parasite of *Neodiprion lecontei* (Fitch) and Jack pine sawflies. One specimen was reared by the Survey from a spruce sawfly collection taken at Rimouski, P.Q., in 1936. Two other specimens emerged on September 23, 1938, from 39 cocoons collected by the Survey at Les Escoumains, P.Q.

An undetermined species of Diptera was reared in 1937 by the Survey from a collection taken at Jocko River, Ont.

Order *Hymenoptera*

Family Ichneumonidae

Agrothereutes glossonae Cush. This is a cocoon parasite. One specimen was reared from 1420 cocoons collected near Young's Brook, N.B., in 1937. R. B. Friend, in correspondence, has reported rearing one female at the Connecticut Agricultural Experiment Station. The females have rudimentary wings.

Aptesis indistincta (Prov.). Eight adults have been reared from collections totalling 12,890 *D. polytomum* cocoons from Maple Grove, Young's Brook, McNamee and Canaan River, N.B. Only the males have functional wings. Arrhenotoky occurs. Several specimens were reared on *D. polytomum* in an incubator operated at a temperature of about 78 degrees F. The eggs were deposited singly in the host cocoons. The incubation period averaged two days and the duration of the four larval stadia, which fed externally on the sawfly eonymphs, was 10-12 days. The cocoon was spun within the host cocoon and the period from cocoon spinning to adult emergence ranged from 20-28 days. The egg is .71 mm. long and is slightly wider at one end than at the other. The first three larval stadia are greenish, so only the mature larva, which is white, might be confused with the larva of the imported parasite, *Microcryptus basizonius* Grav.

Aptesis sp. (probably *pterygia* Bradley). The female of this species also has rudimentary wings. A single specimen was reared by R. E. Balch from a small lot of cocoons collected near Killarney Lake, N.B., in 1936.

Hemiteles sp. One adult emerged from 3,864 cocoons collected in 1935 in Parke Reserve township, Kamouraska County, P.Q. This may have been a secondary parasite.

Mastrus neodiprioni Vier. This is probably a larval parasite. Three adults were reared in 1937, one from a collection of 2,664 cocoons collected at Kingsley, N.B., and 2 from 2,980 cocoons collected at Young's Brook, N.B.

Mesoleius sp. (possibly *viduus* Hgn.). Three specimens have been reared from cocoon collections in Quebec. Two were obtained in 1932, one from a single cocoon collected at Berry Mountain Brook, and one from 44 cocoons collected from the top of Mt. Lyall in Gaspe. The third was reared in 1935 from 1,325 cocoons collected at Parke Reserve, Kamouraska County, P.Q.

Orthocentrus abdominalis Prov. M. L. Prebble reared one specimen from a cage which was stocked with 169 third stage and 77 fourth stage *D. Polytomum* larvae, of which 78 reached the cocoon stage. The larvae were collected on August 23, 1932, from the Berry Mountain Brook area in Gaspe and the parasite emerged on or about September 6, 1932.

Stylocryptus subclavatus (Say). The survey reared one specimen from 70 cocoons collected at Alward, N.B. The parasite emerged in the insectary at Fredericton on August 28, 1938.

Single specimens of four other species of native hymenopterous parasites, including one reared by the Forest Insect Survey, have not yet been identified.

Family Chalcididae

Tritneptis hemerocampae Gir. A colony of 35 adults emerged from a single cocoon found by Mr. M. L. Prebble forty feet up a tree trunk near Berry Mountain Brook, Gaspe. The adults emerged from July 28-30, 1932.

PREDATORS

Order *Hemiptera*

Family Pentatomidae

Podisus serieventris Uhler. This is the most common insect predator attacking *D. polytomum* larvae and is frequently seen feeding on the sawfly in the nymph and adult stages. It is known to attack third, fourth and fifth stages of the sawfly larvae and Prebble has observed it sucking the contents from a *D. polytomum* egg. Dead larvae are frequently taken in larval collections but it is difficult to determine the exact number to be attributed to *Podisus* attack as diseased larvae, which are found occasionally, cannot always be distinguished from those destroyed by pentatomids. In 1937, a 10 ft. x 10 ft. mat was erected beneath a sawfly-infested tree at Young's Brook, N.B., and all of the fifth and sixth stage larvae that fell during the season were collected from the mat and counted. Of a total of 6069 larvae from the mat, 5.5 per cent. were dead, having the appearance of having been sucked by pentatomids. *P. serieventris* was probably largely responsible. A tree similarly treated in 1938 produced a total of 2, 446 fifth and sixth stage larvae, of which 4.8 per cent. were dead. *P. serieventris* appears to be more abundant in New Brunswick than in eastern Quebec and the highest record of abundance was noted near Fredericton, N.B. by Balch, who beat a sawfly-infested tree over a mat, obtaining 48 *Podisus* to 1009 sawfly larvae. Some interesting data were accumulated in 1938 by C. C. Smith, who made weekly sawfly collections at Kingsley, N.B. In these collections one *P. serieventris* adult or nymph occurred to every 420 sawfly larvae. The bugs first appeared in the collections on July 20, when two overwintering adults and one nymph were taken. Nymphs were most numerous from July 20 to August 31 and the 1938 generation of adults first appeared on August 24. No bugs were present after September 21, even though sawfly larvae were still abundant at that time. The biology of *P. serieventris* has been fully discussed by Prebble (4).

Another species, *Podisus maculiventris* Say, occurs in New Brunswick. We have no positive records of it attacking the spruce sawfly in Canada, but Plumb (3) has reported it as being predacious on *D. polytomum* in Connecticut.

Eanus decoratus Mann. Since 1931, studies of the cocoon population of the sawfly have been carried out by the Fredericton Entomological Laboratory in spruce stands in New Brunswick and Quebec. In each plot, quadrats totalling 200 square feet of ground have been examined annually and the old and new cocoons collected and classified. Some of the data from these plots have been published by Balch (1). Of the total cocoons collected the number showing holes which might have been made by predacious insects averaged 5.8 per cent. and ranged from 1 to 25 per cent. Elaterid larvae are common in spruce stands and are sometimes taken in the act of destroying larvae after entering sawfly cocoons. One reared by Prebble was identified as *Eanus decoratus* Mann.

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THE OVIPOSITION HABITS OF SOME OF THE SPECIES OF THE GENUS *EXENTERUS* PARASITIC ON SAWFLY LARVAE

By J. M. Barclay
Dominion Parasite Laboratory
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During the summer of 1938 experiments with several species of imported larval parasites of the spruce sawfly (*Diprion polytomum* Htg.) were initiated at the Dominion Parasite Laboratory, Belleville, Ont. The purpose of these investigations is to obtain as much information as possible upon the biology of many imported parasites about which little is known; to develop a technique for laboratory rearing of these parasites, and to determine the possibilities of production for liberation of any species which seem promising.

In these experiments both laboratory reared and field collected *Diprion polytomum* Htg. larvae have been used as hosts. Spruce foliage, infested with sawfly larvae, was enclosed in cotton parasite collecting cages, 9½ in. x 10½ in. x 15½ in. (inside dimensions), which were already available and proved very convenient (Figure 1). Each cage has a wooden bottom and a removable, transparent front, made from a sheet of xylonite, which provides a means of observation and is also found convenient when it is necessary to renew the spruce foliage, etc. The xylonite front of the cage is provided with a large hole, closed with a cork, through which adult parasites are introduced. During operation a square of moist blotting paper was kept in the bottom of the cage to collect frass, and also to provide a moist place where full-fed sawfly larvae could spin cocoons. The spruce foliage was kept from drying out unduly, by inserting the cut ends of the twigs into a jar of water resting on the bottom of the cage. All of the material was kept in an air-conditioned room at a temperature of 70 deg. F., with 80 per cent relative humidity.

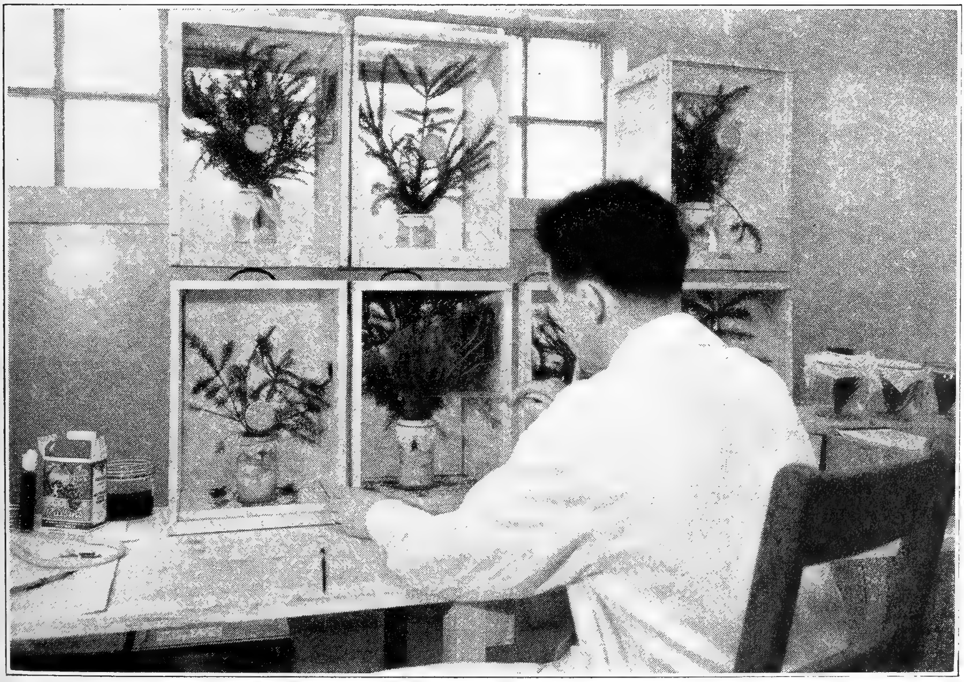

Fig. 1.—Type of cage used in oviposition observations.

During the course of the experiments 40 host larvae, with 10 male and 15 female parasites, were maintained in the cages, when there was a sufficient stock of host larvae and adult parasites to make this possible. These numbers proved practical and convenient to handle. Freshly spun sawfly cocoons were removed as they were spun. Parasitized larvae were removed from some of the cocoons and placed in gelatin capsules for purposes of observation.

This report deals only with observations on the oviposition habits of some six species of *Exenterus* which were available in the laboratory this past summer. Of these, three species were imported from Europe, *Exenterus abruptorius* Thunb. on the host *Diprion sertifer* Geoff., and *Exenterus adspersus* Htg. and *Exenterus tricolor* Roman on the host *Diprion polytomum* Htg. The fourth species, *Exenterus oleaceus* Uch., was imported from Japan on the host *Diprion nipponica* Roh., and the last two, *Exenterus canadensis* Auct. nec. Prov. and *Exenterus diprioni* Roh., were obtained near Belleville, being collected as adults in a small red pine plantation heavily infested with Leconte's sawfly.

In the species under study, two easily differentiated oviposition characteristics were observed, and for convenience, these have been designated as the "*abruptorius*" type and the "*oleaceus*" type. These two types are differentiated by the method of attack of the female upon the host larva, and the type of egg attachment.

In all species the adult female cautiously approached the host larva and inspected it throughout the whole length quite carefully with her antennae. In those species belonging to the "*abruptorius*" type, once inspection was complete the female parasite pounced upon the host larva and oviposition was completed almost instantly. At the same time the host larva became very active, contrary to its usual sluggish nature, and almost always dropped to the floor of the cage. In these species the egg has an imbedded or inserted form of attachment and may be placed on any region of the dorsal or pleural area of the body wall of the host. The egg is always placed at or near a segmental fold and, from dissections of the egg on parasitized hosts as well as from examination of shed skins from host larvae parasitized before the last larval ecdysis, it appears to be inserted in a slit in the cuticula and attached directly to the cuticular epithelium. Following the attachment of an egg, a dark ring develops in the body wall surrounding the site of the egg attachment, making parasitized host larvae quite conspicuous. Figure 2 is a sketch to illustrate the form of egg attachment in those species belonging to the "*abruptorius*" type.

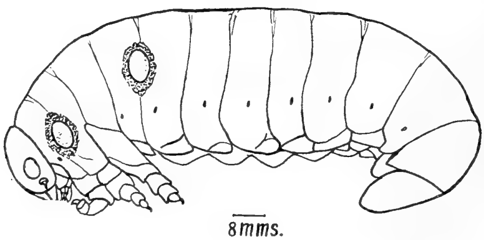

Fig. 2.—Form of egg attachment in species with "abruptorious" type.

Exenterus abruptorius Thunb., *Exenterus adspersus* Htg., *Exenterus diprioni* Roh., and *Exenterus canadensis* Auct. nec. Prov., all belong to the "*abruptorius*" type. In these species the egg is approximately 0.5 mm. long and 0.3 mm. in diameter. There is some variation in the depth to

which individual eggs are imbedded in the body wall of the host. Some are imbedded so deeply that the exterior surface of the egg is almost flush with the surface of the host, while others protrude somewhat. Once the host larva has spun a cocoon and become somewhat shrunken, all eggs appear quite deeply imbedded, due to their position at or near a segmental fold. The eggs of *Exenterus abruptorius* Thunb. differ slightly from those of the other species belonging to this type in that they have a slight greenish cast, while the others are creamy white in colour.

In the species belonging to the *"oleaceus"* type, once inspection is completed, the female parasite flexes the abdomen toward the host larva and when the ovipositor comes into contact with a satisfactory location, oviposition is completed. When the ovipositor comes into contact with any region of the host, other than the anterior region about the thorax, the host larva flexes the body out of the way so that the eggs of the species belonging to this type almost always occur on the anterior thoracic region about the leg bases on the pleural wall or on the ventral portion of the thorax between the legs. In this type the eggs are attached to the body wall by a short, imbedded stalk and, with the exception of the small attachment of the stalk, the egg is free from any other attachment to the host larva. Figure 3 illustrates this form of attachment.

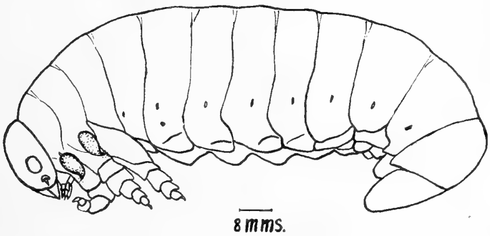

Fig. 3.—Form of egg attachment in species with "oleaceous" type.

Exenterus oleaceus Uch. and *Exenterus tricolor* Roman belong to the *"oleaceus"* type. In these species the egg is about 0.4 mm. long, exclusive of the stalk, and about 0.2 mm. in diameter, thus being slightly smaller and more elongate in form than the eggs of those species belonging to the *"abruptorius"* type. The eggs of these two species are creamy white in colour.

Oviposition occurred readily with all species on fifth and on sixth stage fully-fed *Diprion polytomum* Htg. larvae, although it occurred most readily on the latter stage. Multiple parasitism occurred very often, but this probably can be attributed to the crowded conditions of cage rearing, and doubtless would occur much less frequently under natural field conditions.

These observations make it possible to separate the six species of *Exenterus* into two groups by means of the form of egg attachment to the host larva. *Exenterus abruptorius* Thunb., *Exenterus adspersus* Htg., *Exenterus diprioni* Roh., and *Exenterus canadensis* Auct. nec. Prov. attach the egg to the cuticular epithelium through a slit in the cuticula, giving the egg an imbedded appearance, while *Exenterus oleaceus* Uch. and *Exenterus tricolor* Roman attach the egg to the host larva by means of a short stalk imbedded in the body wall. This distinction between the two types should prove useful in field studies when *Exenterus* eggs are collected on host larvae in the field.

A LABORATORY METHOD FOR THE PROPAGATION OF *MICROCRYPTUS BASIZONIUS GRAV.*

By Thelma U. Green

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During the past season at the Dominion Parasite Laboratory, we were successful in propagating three generations of *Microcryptus basizonius* Grav., of which over 10,000 adults were shipped to the field.

The original stock of this parasite was obtained from *Diprion simile* Htg. material, imported from Poland in connection with the control of the spruce saw-fly, *Diprion polytomum* Htg. During a series of experiments in the winter season of 1937-1938, we observed that *Microcryptus basizonius* grav. would attack the spruce sawfly more readily than it would the pine sawfly on which it was imported, and that the progeny could be reared on *Diprion polytomum* Htg. with no apparent loss of vitality or size. It was decided to try to develop a technique which might be used in large scale laboratory propagation of such an insect, and at the same time secure a few thousand adults for field tests.

Microcryptus basizonius Grav. lays an egg by inserting its ovipositor through the cocoon of its host. Previous experiments had shown that, under laboratory conditions and even with large numbers of host cocoons available, several eggs were frequently laid in one cocoon. Since the technique to be developed was for the purpose of producing quantity, it was thought that perhaps the most economical method might be to concentrate the oviposition, and then to artificially implant the eggs secured, one to each host cocoon.

The oviposition cages employed were glass-topped boxes 8½ by 5½ by 2¾ inches deep. The bottom of each box was fitted with blotting paper, moistened sphagnum moss, and raisins. Into each box were placed five female parasites. Ten "trap" cocoons were submitted to these parasites, and these cocoons were replaced by a fresh supply every two days.

The removal of the eggs from the trap cocoons was very simply accomplished by slitting the cocoon with a sharp scalpel and examining the contents carefully over a black surface. The whitish parasite eggs were easily discernible on the larva and in the cocoon, and were removed with a moistened camel's hair brush.

Transfer of the eggs was made in the following manner: a fresh host cocoon, heat-treated to effect an artificial paralysis of the contents was slit longitudinally with a sharp scalpel, slight pressure being exerted on either end of the cocoon. One egg was inserted through the opening thus made. If just the right amount of pressure were applied, the cocoon would spring closed again upon release of this pressure, leaving no visible sign of the opening. This helped to preserve the moisture necessary for the development of the parasite within the cocoon. Whether or not the egg thus implanted would mature, we found, depended largely upon the technique of transference. In this regard speed and gentle handling were the first requisites. It was necessary that the egg be returned to its natural environment quickly and with delicate manipulation.

These cocoons with the artificially planted eggs were placed in lots of 25 in 1 by 6 inch vials, stoppered with cotton wool covered with cheesecloth, and placed on trays in an incubator room at 73 deg. F. and a relative humidity of 80 per cent. Under these conditions the bulk of adult emergence occurred in the period between the 23rd and the 28th day after planting the eggs in the cocoons.

As was mentioned above, the ten trap cocoons which were removed from the oviposition boxes every second day were replaced by ten fresh trap cocoons. This arrangement was determined by the length of time occupied from oviposition to the eclosion of the egg. Eclosion takes place approximately two days after oviposition and a young larva coming into contact with other eggs often destroys them. Thus it was necessary to open the trap cocoons at least every second day.

Under certain artificial conditions, such as are found in the laboratory, some cocoons are apparently more attractive than others to the adult parasite, for as many as 20 eggs were found in one cocoon, while another beside it would contain none. Had the cocoons merely been removed from the oviposition boxes and placed in the incubator, a very great loss in numbers of parasites would have resulted, since only one parasite can develop in one cocoon. Another advantage of individually transferring the eggs is that a small number of trap cocoons may be used to collect a large number of eggs with very little waste of the host material.

One of our problems was to determine the period over which the "egg-lay" was sufficient to justify the continued use of the same females. It appeared that, after a certain period of egg-lay, the number of eggs obtained from the five females in one box was so few that it was not economical to use these females longer, even though they yet possessed the ability to oviposit for two or three weeks.

In order to determine this period, data obtained from the oviposition of five females, over a period of 28 days in each of a number of boxes, were arranged in tabular form. Five examples are shown in Table A. The figures for boxes 1 and 5 represent the the high and low extremes of oviposition, while those for boxes 2, 3, and 4 show the usual numbers. In table B is shown the average oviposition of five females in each of 13 boxes.

TABLE A.—TABLE SHOWING THE NUMBER OF EGGS OVIPOSITED BY FIVE FEMALE PARASITES IN EACH OF FIVE DIFFERENT OVIPOSITION BOXES

Time in days	Number of eggs oviposited by five females				
	Box 1	Box 2	Box 3	Box 4	Box 5
2	18	17	8	15	14
4	28	28	21	23	19
6	27	31	30	34	17
8	40	43	30	36	23
10	41	34	32	31	18
12	39	31	30	23	12
14	34	35	34	29	20
16	32	28	23	20	19
18	20	19	24	17	20
20	19	24	18	26	16
22	12	17	14	15	13
24	8	23	8	11	13
26	0	10	11	7	0
28	0	1	11	5	0

TABLE B.—TABLE SHOWING THE AVERAGE NUMBER OF EGGS REMOVED FROM THIRTEEN OVIPOSITION BOXES, EACH BOX CONTAINING FIVE FEMALE PARASITES

Time, in days	Average number eggs oviposited by five females in two days
2	16.3
4	23.7
6	27.9
8	32.6
10	28.4
12	24.9
14	30.3
16	24.1
18	22.3
20	16.5
22	14.1
24	11.1
26	6.6
28	5.3

Upon the examination of these tables, we see that the maximum oviposition, on the average, occurs between the eighth and fourteenth days after the first oviposition, and that after 22 days the number of eggs from the five females in each oviposition box was less than the number obtained from five new females. Since the trap cocoons had to be opened and examined every second day, regardless of whether they contained five or 35 eggs, we found that it was more economical to use a fresh set of parasites for propagation every three weeks. Because the females after this three week period were still in splendid condition and capable of considerable oviposition for a period varying from two to three weeks more, they were shipped to the field.

Based on total figures for the three generations, the mortality averaged 41 per cent., practically all of which occurred in the egg stage. Of those remaining 58 per cent. emerged, one per cent. apparently undergoing a condition of diapause.

Microcryptus has proven to be a particularly hardy species in the laboratory, living from 40 to 50 days. The adults may be subjected to a wide range of temperature without apparent injury. They have been kept for two weeks and even longer at 40 deg. F., and were used successfully in propagation after this treatment. The survival of adults shipped to the field was practically 100 per cent.

The technique, as outlined above, has been quite satisfactory and, with a small amount of labour, more than 10,000 individuals so propagated were released in forest areas infested with the European spruce sawfly (*Diprion polytomum* Htg.).

A NOTE ON THE MATING OF *COELOPISTHIA NEMATICIDA* (Pack.) HEWITT

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In connection with the search for parasites to aid in the control of the spruce sawfly (*Diprion polytomum* Htg.), some work was undertaken at Belleville in 1935-36 on the chalcid which we are calling, for the present, *Coelopisthia nematicida* (Pack.) Hewitt and which is, at times, an im-

portant parasite of the larch sawfly, *Pristiphora erichsonii* Htg. It was frequently noticed, that if a host cocoon was opened during or shortly previous to emergence, that pairs of these parasites were discovered in copulation within the cocoon. It was decided to inquire into the matter to determine whether or not a case of "enforced" brother-sister inbreeding actually or only apparently existed here.

Observations disclosed that, although the males in any one cocoon reached maturity ahead of the females, the females cut the emergence holes and were the first to escape. Tests with females which emerged in the usual way, but which were prevented from contact with males outside the cocoon, showed that the progeny were of both sexes. Only a few field-parasitized cocoons of *Pristiphora* were available for examination, but from these and from other data the proportion of males would seem to be about five per cent .

Very often, upon dissection of a cocoon from which a group of females had issued, male adults were revealed, sometimes present with a few female pupae. Apparently the males were awaiting the full development of the females for, as soon as the pupal skin of the female was shed, copulation would be attempted.

Under such conditions as these, it was not possible to make the necessary determination of the nature of the normal parthenogenetic reproduction, without first segregating the sexes, prior to the full development of the males. It was found that this could be accomplished easily, for in the pupal stage the relationship of antenna and foreleg is different in each sex. Virgin females were thus obtained, which, in the numerous cases examined, produced males only. It appears safe to assume that (normally, at any rate) unmated females of *Coelopisthia nematicida* are arrhenotokous and that mating actually takes place before the family is dispersed.

This condition of the mating of the parasites while they are yet within the enclosure of the host cocoon, we believe, occurs also in the case of *Dibrachys cavus* Wlk., a very closely related chalcid.

It would seem that with *Coelopisthia nematicida* we have a case of natural close inbreeding. It would be a rather difficult procedure to determine if, in nature, any outbreeding occurred with this species. It seems probable that it does occur occasionally, but it is also likely that often a great number of generations follow one another in a strictly pure line.

THE PINE SPITTLE BUG (*Aphrophora parallela* Say) AS A PEST OF SCOTCH PINE PLANTATIONS

BY A. H. MACANDREWS

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In New York State the pine spittle bug (*Aphrophora parallela* Say) as a plantation pest has advanced from the ranks of the unimportant to a position of considerable importance. The killing of Scotch pine plantations in different parts of the State has focused the attention of the forester on this insect.

Although this insect has been known for nearly a century, little has been written about it. Fitch, in the "*Transactions of the New York State Agricultural Society*" for 1857, gives a brief discussion which was later copied by Packard in his "*Fifth Report of the Entomological Commission for* 1886". Packard added the comment that the insect was abundant on pitch pine at Brunswick, Maine. Since then scattered reports have appeared. One record from Pennsylvania reports the death of pitch pine (*P. rig-*

ida Mill.), but it was not considered a pest in New York State until a few years ago, when reports began to come in of its abundance in plantations and finally in 1933 Mr. H. L. McIntyre of the Conservation Department reported the loss of Scotch Pine (*P. sylvestris L.*) near Saratoga. Since then there has been a marked increase in the population of the insect and frequent reports of injury and death.

At Great Bear Springs the insect has killed a plantation of Scotch pine and has invaded several other nearby plantations. This area was planted with a variety of species of pine for watershed protection many years ago. All of the common pines are represented in pure and in mixed stands while in some cases the pines have been interplanted with larch and spruce. This gives an excellent opportunity to observe host selection on the part of the insect. At the time of writing (Nov. 21, 1938) the only pine species actually dead or seriously injured is the Scotch pine. This is an extensive plantation with trees averaging 6 in. D.B.H. and 44 feet in height. The average yearly increment is 283 cu. ft. per acre and the average number of trees per acre 612. These figures clearly indicate the growth characteristics of the stand.

History of the insect at Great Bear Springs.—In 1930 some of the plantations were being measured and the spittle bug was reported as being abnormally abundant but the trees did not show any evidence of injury or loss of increment. The insect was again abundant in 1931 but not plentiful in 1932. In 1933 it began to build up rapidly and increased at an alarming rate. Examination of the rings showed little evidence of loss of increment directly due to insect attack. There was, however, loss of increment due to unfavourable climatic conditions and to overcrowding in the stand. This was rather surprising as the insect was so abundant that it was extremely disagreeable to work in the stand. The spittle dropped like rain—the nymphs were crushed on your clothing as you rubbed against the trees—your notes and instruments needed constant cleaning.

In 1937 tips of limbs began to turn reddish brown and in the fall of 1938 the tops were all reddish brown with a few scattered green limbs here and there. This sudden change of color was rather mystifying as we had expected a gradual change from green through pale green, yellow, brown and, finally, reddish brown. Close examination disclosed the presence of great numbers of mites or red spiders. *Paratetranychus ununguis* (Jacobi) was the most common species but *Tetranychus telarius* (L) was also present in considerable numbers. The summer of 1938 was unusually favorable for the growth of mites on conifers in general. Spruce, juniper and hemlock suffered severely.

It is felt that the mite is an important contributing factor in the death of these Scotch pines. In stands where the spittle bug occurred without the red spider the damage was noticeably less. As the red spider increased the tree death rate increased very noticeably. In stands where spittle bug was scarce and red spider abundant the defoliation and discoloration was greater than in the stands where spittle bug was plentiful and red spider scarce.

In the stands of red pine (*P. resinosa* Ait) and white pine (*P. strobus* L.) the spittle bug injury was very light. In fact, the white pine, at time of writing, does not show spittle bug injury at all in the form of discolored foliage. On the other hand, the mite, *Paratetranychus ununguis* caused discoloration and loss of foliage on the white pine. As the mite is much more sensative to climatic conditions than the spittle bug, the ecological relationship of these two insects may play an important part in the ultimate fate of the plantations.

Biology of the Spittle Bug.—The full grown adults appear in July and are present feeding on the bark of the twigs for the balance of the season. When cold weather comes they may be found dead in large numbers with their beaks inserted in the bark. This feeding causes the death of the smaller limbs. The bark becomes rough and scaly and a large amount of resin collects at the point of injury. The adults vary in size from 3/8 to 1/2 inch and there is considerable variation in the markings. The general impression is brown mottled with light and dark spots. The light spots sometimes form a saddle on the wing covers and there is, in some cases, a light line along the middle of the back.

The eggs are laid in late autumn in the bark and hatch in May. The young nymphs produce a frothy-like mass in which they live until full grown in June and July. The nymphs have a tendency to settle down near the ends of the branches in the vicinity of the buds where they suck the sap from the bark until full grown. They may migrate from twig to twig and when mature they migrate from the spittle to the tips of the needles where they change to adults. These adults are common in August and are voracious feeders. The many tiny punctures bleed freely. The bark swells and cracks and the resin dries and turns white and the foliage on the injured twig turns brown. This is followed by the death of the tree. A dying stand looks as though it had been scorched by a light crown fire. As the study progresses we hope to obtain more definite data on host selection and feeding habits of the insect.

FOREST TENT CATERPILLAR IN ONTARIO 1931-1938

By A. W. A. Brown

Division of Entomology
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During the last eight years a serious infestation of forest tent caterpillar, (*Malacosoma disstria* Hbn.) has developed in several regions of Ontario. Reaching its highest intensity in 1935 and 1936, the outbreak is now well on the wane, and appears to be approaching the natural end of a cycle, similar to others which have been frequently observed in the past (Baird, 1916). It is therefore considered an opportune time to present the history since 1931 of this outbreak.

Infestations of forest tent caterpillar differ from those of other forest insects in that the damage to forest trees is not the principal feature. Defoliated poplar, birch and other hardwoods leaf out again when the scourge has passed. Even in the centres of infestation where defoliation has occurred for three or four successive years, only 25 per cent. of the trees are sufficiently weakened to succumb finally. The human activities in the outbreak districts are the most seriously affected. Trains are held up and farms and gardens are overrun by millions of migrating larvae; and town lights attract swarms of moths, causing annoyance to citizens going about their business.

Therefore northern towns and farms, not the forestry interests, are the source of the strongest complaints and demands for action. Forest industries can scarcely be expected to be interested in poplar-birch stands to any extent under present conditions.

This paper is a compilation of reports received from the following sources:—the District Foresters of North Bay, Parry Sound, Sudbury, Sioux Lookout, Port Arthur and Kenora Inspectorates, the officers in charge of the Laniel, Chalk River and Spencerville entomological laborator-

ies and the provincial entomologist of Ontario. Use was made also of private communications from Mr. J. A. Brodie, Dr. T. L. Tanton, The. Rev. Joseph Gravelle, and Messrs. R. Boultbee, J. McNamara, and A. V. Cox. The Insect Pest Review of the Division of Entomology has furnished useful information. Much has been gleaned from newspaper articles and local news.

There are two main regions susceptible to large outbreaks. The first lies west of Lake Superior and extends eastwards as far as Lake Nipigon. The second lies in the Ottawa Valley and extends north to Lake Abitibi, westwards to the north shore of Lake Huron, and southwards to Muskoka and Victoria Counties. Further south and west in Old Ontario the forest tent caterpillar is almost entirely superseded by the eastern tent caterpillar (*Malacosoma americana* Fab.) Between these two regions lie the great spruce and balsam flats of northern Algoma.

The eastern region will first be considered, the areas infested in successive years being indicated in Figure 1. The beginning of the present infestation can be said to have occurred in 1930 in the district around Eau Claire. Thence it moved eastward to achieve the position indicated in 1933, being also observed at Nipissing Chute. Another centre appeared at Nairn in 1932, growing larger in 1933. Meanwhile a widespread but patchy infestation had become severe in eastern Ontario.

The Nipissing and Sudbury infestations grew in 1934 and had covered a considerable area by 1935. In 1935, there was already severe defoliation

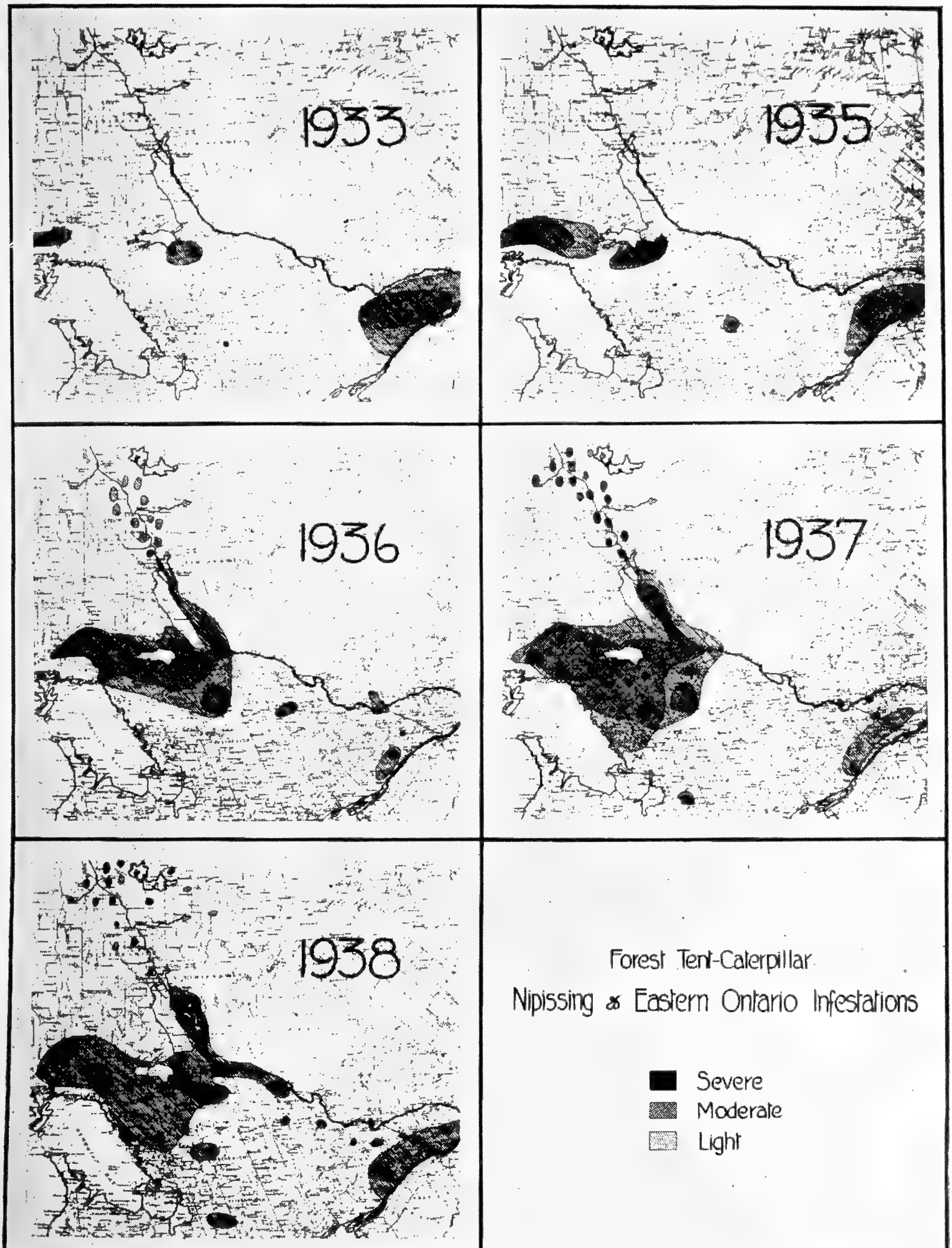

Fig. 1.—Nipissing and Eastern Ontario of forest tent caterpillar 1933-1938.

in the Powassan area, this being the peak year in this centre of infestation. The tent caterpillar situation in eastern Ontario was still serious, there having been an increase in population after a decline in 1934. There is a record of a small outbreak near Bancroft. Incidentally it may be noted

that, at that time, a severe infestation in south-central New Brunswick was declining from a peak in 1934.

In 1936, following a spring characterized by lack of frost, the Nipissing infestation assumed serious proportions. Records for this year are more complete and moderately reliable, as a result of the successful establishment of the Forest Insect Survey system. Outbreaks were reported from Algonquin Park, and across the Ottawa River into Quebec. The Sudbury infestation, repeating this eastward trend, moved northeast and southeast to meet the Nipissing infestation and surround the lake. In general, this may be considered the worst year. In the centre of the infestation there was already high mortality due to a muscardine fungus, and the large parasitic fly, *Sarcophaga aldrichi* was abundant.

In 1937 the infestation spread still further south and east. The subsidence in the original focus continued, but there have been important extensions southwards into Muskoka, eastwards down the Ottawa River for a short distance and northwards up the river to Lake Temiskaming, with spot infestations observed as far north as Lake Abitibi. The centre of gravity of the Sudbury infestation also has moved northeast. The outbreak in eastern Ontario was light but again increasing.

1938 represents a year of great extension but little intensity. Possibly the greatest population was attained at Kipawa Lake, with some patches of severe infestation on the northern boundary of the Sudbury area. Small outbreaks are being encountered well to the south for the first time, e.g. Dorset, Severn River and Peterborough. The spread down the Ottawa River has become quite serious, and threatens to meet the resuscitated eastern Ontario infestation.

The above account completes the picture for the Nipissing infestation. The western infestation, though considerably more serious and widespread, is less completely reported. As early as 1931, scattered patches of infestation were observed in Kenora and the western part of Sioux Lookout district. In 1933 an infestation had already developed (Figure 2). The main outbreak was centred on the western end of Lac Seul, while foci of infestation were appearing farther southeast at Quetico Lake and in Gillies Township, for several years a centre of infestation.

1937, with a cold wet spring, witnessed a general subsidence, though the situation just west of Port Arthur was still serious. Populations disappear in the west, but there is evidence of new infestations in the east. The picture in 1938 is a logical sequel. There was no longer trouble west of Port Arthur. But there occurred serious infestations along the Nipigon highway, and all the shores and islands of Lake Nipigon were defoliated.

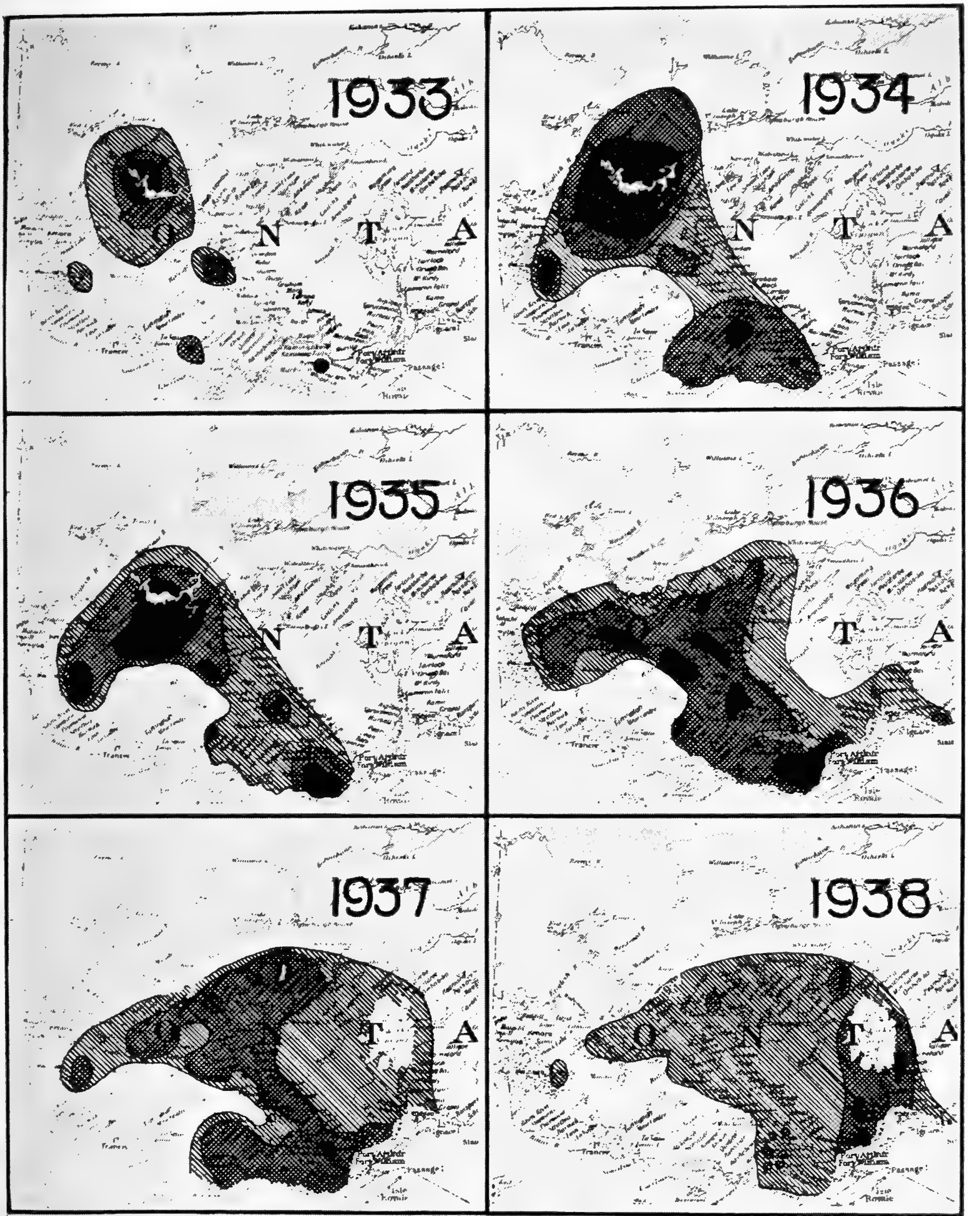

Fig. 2 Western Ontario Infestation of the Forest Tent-caterpillar

An examination of this past record reveals several important features. Firstly, that new infestations arise in several widely separated areas more or less simultaneously. Secondly, that in successive years a steady movement eastwards may be detected, or more exactly to the compass

point E.S.E. Thirdly, that outward spread of an outbreak is followed by subsidence at the centre of the infestation. And fourthly, that the most severe attack lasts for a period of three years, followed by quite a sharp decrease.

During the period of severe outbreak controlling factors gradually assert themselves. The parasite population increases, notably *Sarcophaga aldrichi* Park; by 1937 this large tachinid fly was so abundant as to be reported a nuisance to campers. Muscardine fungus may attack larvae and pupae, as in the Powassan area; or wilt disease may kill the caterpillars on the trees, as reported from Gillies Township. The larvae population may be so high as to cause an early failure of food supply that cannot be remedied by migration. Finally late spring frosts, as in 1937, may take their toll of young larvae.

Conditions conducive to an outbreak may now be discussed. The dominant factor here is the existence of extensive continuous areas of second-growth poplar and birch, especially in the 30 to 40 year age-class. These forest types are a direct result of fires following inadequately supervised woods operations, mining and colonization. With the "opening-up" of the continent conditions are created which favour outbreaks of this pest in increasing intensity, as pointed out by Baird in 1916.

The most susceptible areas to attack by forest tent caterpillar are the Nipissing-Georgian Bay district and the region extending from Lake Temiskaming to Lake Abitibi (J. A. Brodie, personal communication). Here the poplar is continuous, being scattered also throughout the softwood stands. As observed by Brodie, where poplar-birch stands are restricted to patches, even as large as several square miles, the susceptibility is very much reduced. Table I, compiled from work by Sharpe and Brodie, summarizes the susceptibility of all areas in the province by the forementioned criteria.

TABLE 1.—AREAS OF POPLAR-BIRCH IN ONTARIO SUSCEPTIBLE TO ATTACK BY FOREST TENT CATERPILLAR (FROM SHARPE & BRODIE)

Region	Total Poplar-Birch	Moderately Susceptible	Very Susceptible
Sudbury	45	16	28
Rainy River	16	54	35
Central Divide	52	34	23
Kenora Extension	19	57	19
Clay Belt	19	42	1
Nipigon Extension	36	39	7

We have had an idea of what areas are susceptible. We have a rough idea of the course of past infestations. How may future outbreaks be averted? The paramount rule in forest fire protection would seem to have its parallel here,—spot the infestation when it is still small. Then intensive mechanical and biological control measures may be attempted. The prime essential for the success of such a programme is a thorough Forest Insect Survey system.

The author wishes to acknowledge the assistance of Mr. R. G. Calvert in preparing the illustrations.

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SOME NOTES ON THE GYPSY MOTH ERADICATION CAMPAIGN IN NEW BRUNSWICK, AND THE JAPANESE BEETLE PREVENTIVE WORK [1]

By LEONARD S. MCLAINE

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Gypsy Moth. So much has been written and said about the gypsy moth that it is unnecessary to go into detail, with regard to its life-history and control, other than to mention that over $45,000,000 has been spent in the Eastern United States in an endeavour to keep it under control.

In 1922 an International Conference was called to consider the gypsy moth situation owing to the fact that the pest had been spreading westward until it had reached the Hudson River Valley and was threatening to invade the Adirondack area in New York State. As a result of this conference, it was decided to establish a barrier zone extending along the Champlain and Hudson River Valleys from the Canadian Border to Long Island Sound, and approximately twenty miles wide. This zone was to be scouted continuously, and any infestation found was to be eradicated without delay. The Federal Department and the various States concerned were to co-operate in the campaign. The Canada Department of Agriculture agreed to patrol the area north of the International Boundary.

As a result of this scouting in southern Quebec, a large colony was discovered at Henrysburg, Quebec; a total of 2,908 egg clusters being found and treated. Steps were immediately taken to eradicate the pest, and spraying operations were carried on for three years before eradication was completed. During this time, a quarantine was placed by both Canada and the United States on an area covering approximately 3,500 square miles, which either prohibited or restricted the movement of Christmas trees, etc., likely to harbour the pest. The cost of eradicating this outbreak, to the Province of Quebec and the Dominion Department, was approximately $150,000. Since that time, a border patrol has been maintained along the International Boundary, and although small outbreaks have been found to the south, from time to time, no further infestations have been discovered in Quebec.

The extreme eastern section of the infested area in the United States has been cause for considerable concern for over 20 years, as the gypsy moth has been slowly but surely migrating northeastward through the State of Maine towards the New Brunswick border. Scouting in New Brunswick has been carried on from time to time, and also in the State of Maine.

In the summer of 1936, the United States Bureau of Entomology and Plant Quarantine reported an outbreak at Cooper, Maine. The infestation was on high land, approximately 20 miles from the New Brunswick border. Subsequent scouting revealed small colonies in the towns of Calais and Milltown, and at six other points in the State of Maine, just across the St. Croix River from the New Brunswick border. As a result of these discoveries, plans were made to start further scouting in New Brunswick, with the result that several small incipient infestations were found in the towns of St. Stephen and Milltown, and at one or two points outside.

1 Contribution No. 5 from Plant Protection Division, Production Service, Department of Agriculture, Ottawa, Canada.

Scouting carried on in 1937-38, and up to November 4, 1938, shows that 104 egg clusters have been found in the towns mentioned, and at six points outside. During the summers of 1937 and 1938, a thousand or more trees were burlapped in the vicinity of the infestations in St. Stephen and Milltown. The burlaps were turned at frequent intervals; and 795 larvae were taken and destroyed. The outside infestations have apparently been cleaned up, as no further egg clusters have been collected at any of these points.

The situation in the towns is, however, much more difficult on account of high elms, many of which need pruning and trimming; and the fact that egg clusters have been found on private property adjacent to buildings and barns, some of which are in a poor state of repair. These conditions make control and eradication difficult, and it may be necessary to carry on spraying operations next season. The situation can be said, however, to be well in hand; and it is hoped that the pest will ultimately be eradicated.

Japanese Beetle.—Although not known to be established in Canada, the Japanese beetle has been a matter of concern for a number of years. It was discovered in New Jersey in 1916, and is believed to have been introduced on iris roots from Japan a few years previously. The life-history and habits of this insect are so well known, that it is unnecessary to repeat them, other than to mention that the adults feed on a great variety of plant life, the leaves of various trees and shrubs, fresh fruits, vegetables, and even flowers; and the larvae, whose life is spent in the ground, feed on the roots of grasses, etc.

The insect can spread either by direct flight, or be transported in various commodities in the adult stage, or in the soil around plants, or even in earth itself, compost, manure, etc., in the egg or larval stages. Since its discovery, it has spread over a large area and has also been found in isolated points far removed from the general infested area. Unfortunately, a number of these are adjacent to the Canadian border. In all such cases, however, the infestations are extremely light.

Although a quarantine is maintained by the United States Department of Agriculture on the movement of products likely to harbour the pest from the infested area, there is always the danger of the insect being carried in other commodities or in other ways, especially at the time of flight during the summer. Special precautions have been taken in Canada since 1927, in an endeavour to prevent the introduction of this pest, especially in the Niagara Peninsula, which is considered to be a particularly vulnerable spot, on account of its climatic conditions, the production of crops, etc., particularly suitable to the pest.

In 1930, special instructions were issued to all ports of importation to examine, in addition to nursery stock and other products covered by the quarantine, plant products through freight, express, molasses tank cars, freight cars generally, etc., and, in fact, all commodities coming directly to Canada from the heavily infested areas in the United States at the time of maximum beetle flight.

In 1934, it was decided to station additional inspectors at Yarmouth, Nova Scotia, and at points in Ontario, to take care of this work. In addition, Japanese beetle traps were placed at what might be called strategic points, such as tourist camps, freight yards, etc., to determine whether the insect had actually invaded Canadian territory.

During the past season, a total of 1,722 traps were put out, and these were placed at Yarmouth, N.S., St. John, N.B., Montreal, Toronto, the Niagara Peninsula generally, and the Windsor district. In addition, traps were placed in the Belleville area. At seaports, special attention has been paid to ships arriving from New York, Philadelphia and Boston, and leaving during the period of beetle flight. This past summer, 26 live beetles and 56 dead ones were found at Yarmouth, N.S., on the New York boats. Eight dead beetles were found at Quebec, and 19 dead beetles at Montreal on the decks of cruise ships coming from New York. In addition, dead beetles were found in automobiles coming off the boats at Yarmouth, in freight cars at Toronto and Niagara Falls, and even in automobiles as far west as Windsor, Ontario.

As was mentioned at the beginning, this insect is not yet known to have become established in Canada, and it is to be hoped that its arrival may be delayed for many years, in view of the precautions that are being taken by the United States Department of Agriculture in inspecting and certifying the commodities most likely to carry the pest, and the precautions that are being taken in Canada to prevent its introduction.

THE FOREST INSECT SURVEY FOR 1938

By A. W. A. Brown

Division of Entomology, Ottawa

A considerable advance has been made over last year in the work of the Forest Insect Survey. The number of samples received was 470 for the Vernon laboratory, 1367 for Fredericton, and 3280 for Ottawa; representing a total of 5117—an increase of 38% over 1937. Areas sampled range from Newfoundland to Vancouver Island and northwards to Great Slave Lake. The survey is nearing its objective of covering all the forest areas of Canada. A notable advance was made in collections from southern Ontario.

TABLE 1.—REARING RESULTS FOR SAWFLIES OBTAINED IN THE SURVEY TENTHREDINIDAE—SPRING EMERGENTS, 1937

Species	No. rec'd	Emergence av. day-degrees	Sex ratio	Rearing %'s		Parasites	
				Larval	Cocoon	% para-sitism	No. of species
Diprion polytomum Htg. European spruce sawfly	13837	325	99.7	51	38 (3)	0.11	5
Diprion frutetorum Fabr. Nursery pine sawfly	10	525	87	80	100	0	
Neodiprion lecontei Fitch Red-headed pine sawfly	1658	500	73		35	16	14
Neodiprion pinetum Nort. Black-headed pine sawfly	679	400	77	53	53	5	6
Neodiprion abietis Harr. Black-headed fir sawfly	522	July 12-Aug. 20		79	82	5	8
Neodiprion dubiosus Schedl Red-headed jack pine sawfly	1460	375	65	72	56	11	11
Pikonema alaskensis Roh. Yellow-headed spruce sawfly	3013	675	66	15	11	11	10
Pikonema dimmockii Cress. Green-headed spruce sawfly	594	550	100	16	19	5	2
Pristiphora erichsonii Htg. Larch sawfly	1613			42		19	1

TABLE 2.—REARING RESULTS FOR LEPIDOPTERA OBTAINED IN THE SURVEY

LEPIDOPTERA—SPRING EMERGENTS, 1937

Species	No. rec'd	Pupation	Emergence av. day-degrees	Rearing %'s		Parasites	
				Larval	Pupal	% parasitism	No. of species
Panthea acronyctoides Wlk. Spruce tufted caterpillar	33	Aug. 9-Sept. 13	450	79	77	15	3
Elaphria versicolor Grt. Fir harlequin	71	Aug. 11-Oct. 2	325	23	38	6	1
Feralia jocosa Gn. Green-striped caterpillar	78	Aug. 1-Sept. 16	125	53	2	0	1
Herculia thymetusalis Wlk. Spruce needle worm	20	Sept. 15-Nov. 22	?	35	29	5	1
Argyrotaenia lutosana Clem. Fall spruce needle moth	50	Sept. 1-28	225	82	66	15	4
Semiothisa granitata Gn. Green spruce looper	1561	July 9-Oct. 8	300 (July 24-Oct. 21)	42	34 (13)	33	15
Caripeta divisata Wlk. Grey spruce looper	140	Sept. 2-Oct. 22	850	51	63	18	5
Eupithecia palpata Pack. Brown spruce looper	18	Aug. 17-Sept. 23	275	100	94	0	—
Hydriomena divisaria Wlk. Transverse-banded looper	101	Aug. 25-Oct. 14	300	78	66	8	4

Before discussing the results of the 1938 survey, it is necessary to present a summary of the rearings of the material obtained in 1937. Table 1 covers the sawflies. All of these, with the exception of *Neodiprion abietis,* are spring emergents. The amount of incubation necessary for emergence after hibernation is given in the third column in terms of day-degrees of effective heat, using arbitrarily 50 deg. F. as the threshold of development, (Glenn, 1922). Survival figures bring out in a general way the hardiness to rearing conditions of *Neodiprions,* especially *N. abietis,* and the high mortality in the *Pikonemas.*

The bulk of the material consisted of the European spruce sawfly—about 14,000 specimens. The second or summer generation amounted in the aggregate to only 3 per cent. of the total, though in the Temiskaming infestation as much as 40 per cent. of cocoons produced summer emergents. Thirty five per cent. of the adults emerged in the following spring, there being little difference in this year's material between the Gaspe and western Quebec samples. Seven specimens of native parasites were obtained, giving a percentage parasitism, for the Ottawa survey material only, slightly higher than in 1936. The subject of native parasites is treated in detail elsewhere (Reeks, 1938). Interesting parasite relationships were found among the different species of sawflies, which will be discussed when more data have been obtained.

Table 2 tabulates the results for Lepidoptera emerging in the spring, all of which are to be found feeding upon the foliage of spruce. In general, it may be observed that, as is nicely shown in the sawflies, the larger the species the greater the amount of effective heat required to produce emergence. There are two notable exceptions here, namely the small *Caripeta,* which has a delayed emergence, and the large *Feralia,* which when it emerges at all does so early. This table strikingly shows that the very common green spruce looper (*Semiothisa granitata*) is host to numerous parasites representing a great diversity of species.

The outstanding features of the 1938 survey may now be considered. The summer in Eastern Canada was characterized by temperatures above normal throughout, and by excessive rainfall in all months except June.

The decrease in the population density of the European spruce sawfly (*Diprion polytomum* Htg.) in the infested areas of Quebec north of the St. Lawrence and in Ontario may perhaps be attributed largely to climatic factors (Fig. 1). Moreover, promising results have attended the liberations of *Microplectron fuscipennis* Zett., the percentage parasitism by this species alone averaging as high as 0.53 per cent. for all the area south of the St. Lawrence (summer emergence from 1938 cocoon samples).

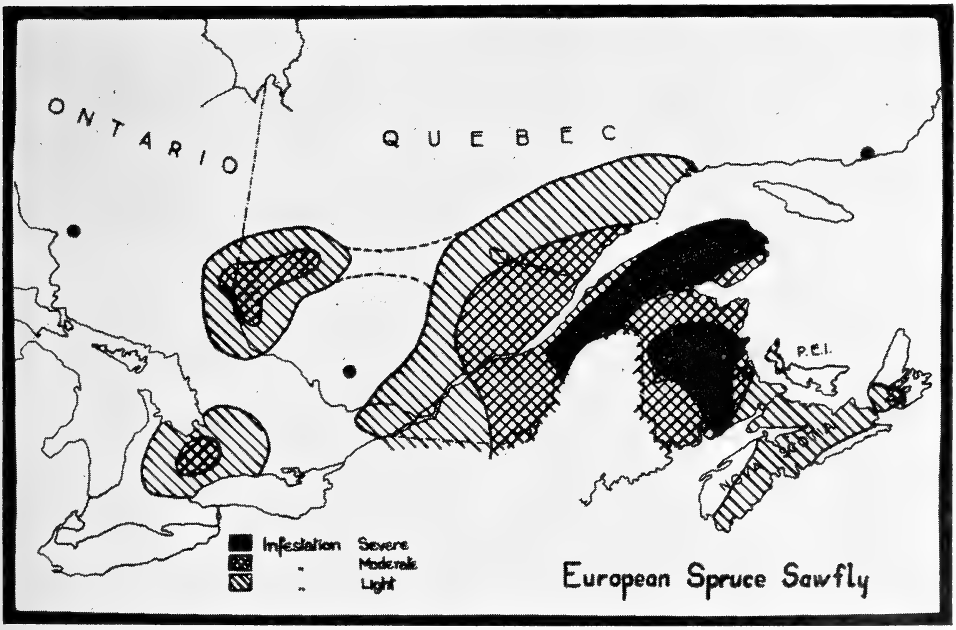

Fig. 1.—Degree of Infestation of European Spruce Sawfly in 1938.

The reports received in 1938 suggest that the boundary of moderate infestation has apparently receded on the north shore, and in northern Quebec there is a recession even in the distribution outline. However, an important new area of moderate infestation has been discovered in southern Ontario. Population densities south of the St. Lawrence are derived from quantitative larval and cocoon samples analysed by the Fredericton laboratory.

The infestation of red-headed pine sawfly (*Neodiprion lecontei* Fitch) in the Muskoka-Nipissing districts has declined to a low level. However, outbreaks occurred in other areas such as Sault Ste. Marie, Orangeville, Gananoque, and Berthierville. On the other hand, the black-headed fir sawfly (*Neodiprion abietis* Harr.) is causing trouble on balsam at Lake Winnipegosis and Buckingham, Que., on jack pine in the Kenora-Rainy River area, and is unusually prevalent on spruce.

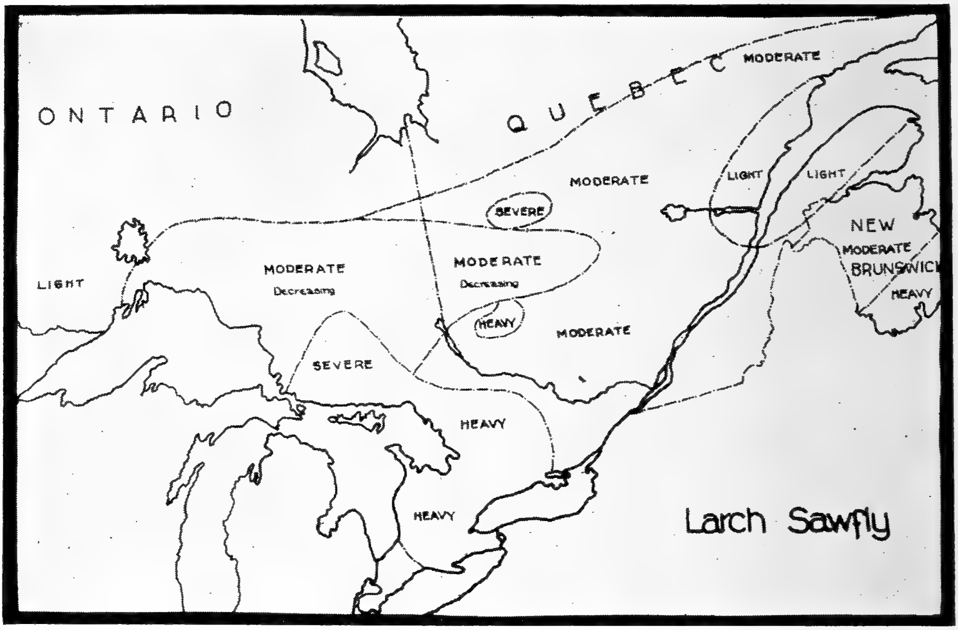

Fig. 2.—Degree of Infestation of larch sawfly in 1938.

The larch sawfly (*Pristiphora erichsonii* Htg.) has increased in infestation intensity in some regions and decreased in others (Fig. 2). The outbreak north of the height of land in Ontario and western Quebec has moderated and the trees show some possibilities of recovery. There is a moderate infestation with some severe areas in the rest of Quebec and in northern New Brunswick. It is in southern Ontario and southern New Brunswick that the situation is serious this year. Heavy defoliation in Ontario extends northwards to Foleyet in the Sudbury district. West of Lake Superior there are no serious infestations. The principal parasite obtained from most of these regions was the tachinid fly, *Bessa selecta;* while a few *Mesoleius* were obtained in some areas.

Interesting records of complete defoliation of hardwoods by the saddled prominent (*Heterocampa guttivitta* Wlk.) came from Durham and York Counties in Ontario. This recalls the infestation some years ago at Franklin Centre, Que. Damage to maple by the green-striped maple worm (*Anisota rubicunda* Fab.) is reported from the Petawawa Forest Reserve. An unusual case of defoliation of mixed hardwoods by *Anisota virginiensis* Dru. occurred on an island in the Ottawa River near Fort Coulonge.

This year (1938) has witnessed increase and some outbreaks in the case of both the walnut caterpillar (*Datana integerrima* G. and R.) and white-marked tussock moth (*Hemerocampa leucostigma* A. and S.) in

southern Ontario. More important is the increased infestation of fall webworm (*Hyphantria textor* Harv.) Serious damage occurred in the St. Lawrence Valley from St. Lambert to Valleyfield, and moderate infestation as far as Belleville; this species was abundant also in southern Manitoba and in parts of the Niagara Peninsula.

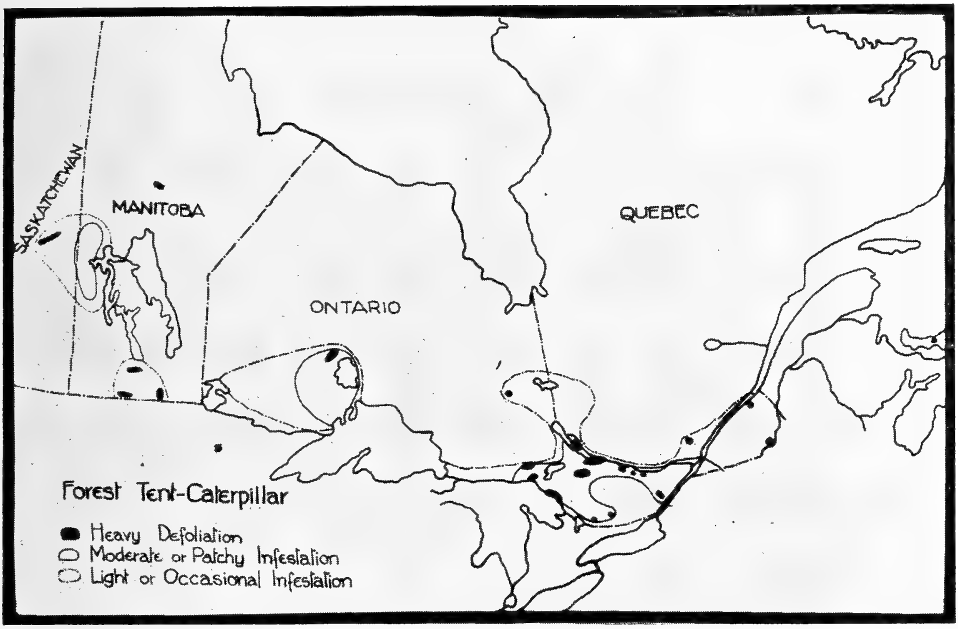

Fig. 3.—Degree of infestation of forest tent-caterpillar in 1938.

The forest tent caterpillar (*Malacosoma disstria* Hbn.) appears to be at the end of an infestation period, being on the wane in the original centres and severe in patches in the outlying areas (Fig. 3). Such is certainly the case in Ontario, the two main infestations of which are discussed elsewhere. There is a heavy infestation along the Saskatchewan River from Nipawin 25 miles downstream. It is interesting that here the large ground-beetle *Carabus taedatus* Fab. is reported as a valuable control factor. A patchy infestation in northern Manitoba extends from the Duck Mountains north to The Pas. Southern Manitoba has severe infestations in the regions of Portage la Prairie, the Red River, and the Pembina Valley.

The Quebec infestations of forest tent caterpillar at Megantic and Levis continue to be severe though parasites are abundant; a new outbreak is reported from Rawdon. One point in Prince Edward Island represents the only serious infestation reported from the Maritimes. It is interesting to note that the western tent caterpillar (*Malacosoma pluvialis* Dyar) was a common admixture even as far east as the Ottawa Valley and Abitibi County, Que.

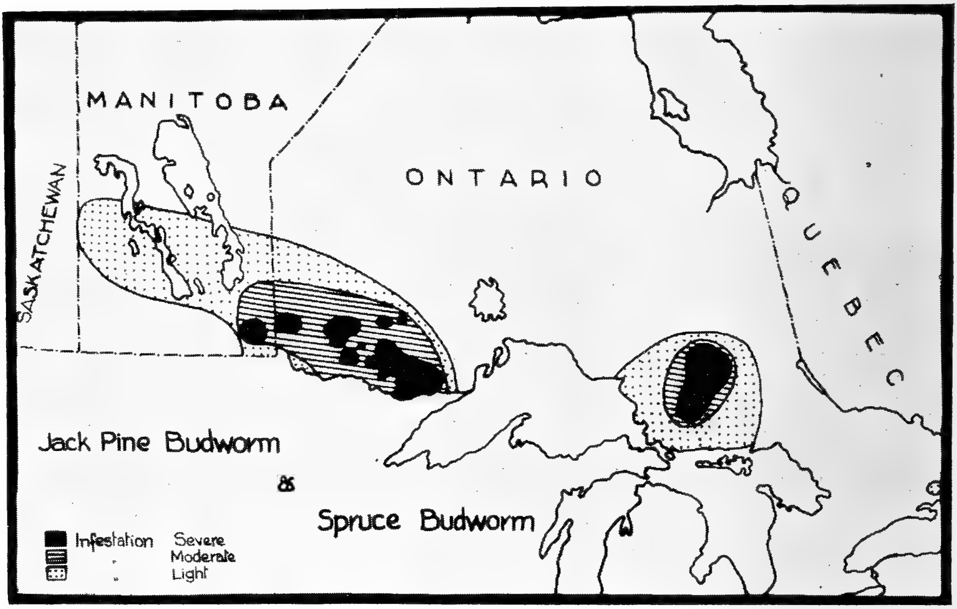

Fig. 4.—Degree of infestation of spruce budworm and Jack pine budworm in 1938.

The jack pine budworm (*Cacoecia fumiferana* Clem.) has caused a serious and widespread infestation west of Lake Superior, and is apparently spreading eastwards (Fig. 4). Whereas the intensity in the greater part of Manitoba is light, serious concentrations are present in the Sandilands reserve, and in the Kenora, Rainy River and western Thunder Bay districts of Ontario. Parasitism in the areas of older infestations in southeast Manitoba was as high as 79 per cent., decreasing regularly as one approaches the areas of newer infestation to 25 per cent. in the Port Arthur district.

During the past few years, the spruce budworm (*Cacoecia fumiferana* Clem.) has built up a very heavy population on spruce and balsam in the Algoma district of Ontario. This infestation extends from the Mississagi River northeast to Foleyet, covering a pear-shaped area 100 miles long and 50 miles wide. It is probable that the balsam and most of the spruce, attacked in 1937 and 1938, will be killed. A light infestation is reported from Westbrook, just west of Kingston.

Another outbreak which has been developing for the last few years is that of the hemlock looper (*Ellopia fiscellaria* Gn.) in the area between Parry Sound and Lake Muskoka, where a considerable amount of hemlock has been destroyed. There is also a moderate infestation at Owen Sound, and the looper is common on spruce, balsam and white pine throughout the Parry Sound forest inspectorate.

It may be emphasized that the Forest Insect Survey has two functions; firstly, to gather data on the distribution, biology and parasitism of all species encountered, and secondly, to record, correlate and distribute information on infestations reported from any point in the Dominion. The steady growth of this project shows that it answers a real need.

The author wishes to acknowledge the assistance of Mr. H. Raizenne in preparing the illustrations.

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FURTHER OBSERVATIONS ON THE BIOLOGY OF THE APPLE MAGGOT (*Rhagoletis pomonella* WALSH)

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At the seventy-third annual meeting of this society the author presented a paper dealing with the emergence and pre-oviposition period of the apple maggot. The work of the past two years has confirmed the data given at that time but has added nothing new on these points beyond the recording of an earlier and longer period of emergence of first brood flies, namely September 12 to November 17.

The present paper treats of insectary and rearing technique, fecundity of the female, longevity of adults, host plants, and includes a few notes on the *Cornus* fruit fly.

When our studies were begun in 1933, a review of the literature at hand indicated that workers in the past had had little or no success in obtaining normal behaviour of this insect under confined conditions. Our first problem, therefore, was to discover a reasonably satisfactory technique for handling the flies and this involved work with different types of cages and with different diets.

Insect Material.—The insect material was obtained by rearing from infested fruit collected for the most part shortly after it had dropped from the tree. When flies alone were required, the fruit was placed on the soil in recovery cages so that the larvae matured and entered the soil in a very natural way. Where definite numbers of larvae were wanted, the fruit was placed in wooden boxes with coarse screen bottoms through which the maggots dropped into glass jars via factory cotton funnels. The larvae were counted and transferred daily to soil in flower pots and ground cages located under orchard trees.

Only spring brood adults were used in the insectary. The flies were collected within 24 hours or less after emergence and were transferred by means of sucker tubes and glass vials. In our earlier experiments colonies of both sexes numbering up to about 200 were placed in each cage, but during the past two years work was done with individual females plus one or more males to a cage.

Cages.—Several types of cages located at various heights and in differing exposures to light were used in the insectary. Exposure of the caged flies to sunlight for a part of each fine day was assured by removing the canvas insectary roof in the morning and replacing it at night. For the most part the cages were constructed of 16 mesh galvanized wire cloth. The shapes and sizes used were: (1) cylinders 7 and 12 inches in diameter and 12 to 16 inches in height; (2) modified Riley cages 10 inches in diameter and 14 inches in height (with glass fronts); (3) cones 7 inches at the base, 2½ inches at the top and about 12 inches high. These were all set in trays of sand. Access to the insides was obtained by the use of zippers, glass fronts or cotton sleeves. In 1938 another type, 6 by 7 by 8 inches made with wooden frame and floor, cotton sides and glass top was tried. It is worthy of note here that response from the flies was obtained in each of the various types of cages when the better diets were fed.

Diets.—Water was supplied to each cage by means of wicks extending upwards from jars of water, and the soil at the bottom of the cages was kept moist as well. Liquid diets were fed either by the wick method or by placing cotton batting in shallow dishes and saturating it. Dry foods were placed in shallow dishes within the cages. With the "Standard Diet" (No. 2) the food was placed on top of the water jar in contact with the wick and was thus kept moist. All foods were renewed often enough to keep them in a fresh condition. Fruits were suspended at the top of the cages.

The following diets were used:

No. 1—Sugar, molasses and Jamaica rum smeared on the fruit and leaves.
No. 2—Yeast, raisins and honey, moistened by wick (standard diet).
No. 3—Yeast, honey and raisins fed dry; water separate.
No. 4—A mixture of water 46%; milk 46%; honey 5% and Royal yeast 3% by volume (standard milk diet).
No. 5—Standard milk plus one teaspoonful wheat germ to each 10 ounces.
No. 6—Standard milk plus one teaspoonful powdered liver to each 10 ounces.
No. 7—Standard milk with dried Brewer's yeast instead of Royal yeast.
No. 8—Standard milk plus one capsule of wheat germ oil to each 5 ounces.
No. 9—Standard milk plus 8 small drops of "Viosterol*" to each 2 ounces.
No. 10—Proteose-peptone**, yeast and granulated sugar (1-1-4 mixture).
No. 11—Honey dew secreted by the green apple aphis on seedling in the cage.
No. 12—Yeast and granulated sugar fed dry.

Results Obtained From the Feeding of Adults.—In our earliest work we fed sugars, molasses and Jamaica rum both diluted and undiluted, but these failed to induce oviposition. We next began the use of yeast, honey and raisins as in diets Nos. 2 and 3. There was a response in fifty per cent. of the cages with the former and 100 per cent. with the latter. Diets Nos. 4, 5, 6 and 7 gave from 17 to 60 per cent. response and diets Nos. 8 and 9 failed entirely. Viosterol, as used in No. 9 was highly toxic and flies fed on Brewer's yeast (No. 7) died in less than average time. Proteose-peptone (No. 10) was very heavily fed upon by the flies, but only brought an oviposition response in 34 per cent. of the cages in which it was used. The one experiment with aphid honey dew gave unpromising results. Table No. 1 shows the comparative oviposition results for the various diets used.

TABLE NO. 1.—DIET AND OVIPOSITION RESPONSE OF THE APPLE MAGGOT

		With oviposition		Without oviposition	
Diet No.	No. of tests	No. of flies	Per cent	No. of flies	Per cent
3	9	9	100	0	0
7	5	3	60	2	40
2	16	8	50	8	50
5	6	3	50	3	50
10	12	4	34	8	66
6	15	4	26	11	74
4	6	1	17	5	83
1	12	0	0	12	100
8	2	0	0	2	100
9	2	0	0	2	100
11	1	?	(3 eggs laid)		

*Viosterol—a preparation made by Mead Johnson & Co., of Belleville, Ontario and said to contain not less than 10,000 International Vitamin D units per gram.
**Proteose-peptone—A protein digest containing proteoses, peptones and amino acids, used in bacteriological culture media and prepared by Difco Laboratories, Detroit, Michigan.

Discussion.—While the above data indicate that diet is perhaps the greatest factor in obtaining oviposition response, it will be remembered from my former paper (Annual Report of the Ent. Soc. of Ont. 1936) that state of maturity of the fruit, light and temperature are contributing factors. Since we have had response from several indivdual females, we no longer feel that crowding or concentration of the flies is a necessary factor to induce egg laying. We have not yet, however, learned the full combination of conditions required to bring a response in every case.

Fecundity of the Apple Maggot.—In 1937-38 efforts were made to obtain definite fecundity records. During the two seasons 52 females were confined singly in cone cages with 2 to 10 males in each case and the most promising diets were used. Only four produced eggs, the numbers laid by each being respectively 1, 31, 46 and 132.

During the season of 1938 a colony of 20 females and 15 males feeding upon the proteose-peptone sugar and yeast diet (No. 10) produced 1145 eggs or an average of 57.25 eggs per female. This average is in all probability lower than the normal for flies in the orchard, and is quite low when compared with the records running as high as 277 eggs per female obtained by R. W. Dean* at Poughkeepsie, New York.

Longevity of Apple Maggot Adults.—The duration of adult life for 205 flies which emerged at various times and which were fed various diets totalled 3743 days. The maximum, minimum and average periods in days were respectively 63, 2 and 15.5 for 105 males, and 62, 4 and 21.6 for 100 females, the females having lived an average of about 6 days longer than the males. The maximum life of a male was obtained on a diet of dry yeast and granulated sugar (12) and that of a female on a diet of honey, raisins and yeast, water being supplied in each case by means of a wick.

The longevity of flies under natural conditions in the orchard can only be estimated. In each of the six seasons in which observations were made, adults were seen in numbers in the orchard 3 to 5 weeks after spring brood emergence in the cages had ceased and prior to emergence of first brood flies. Spring brood flies lived in the insectary as late as November first, and first brood flies survived in the laboratory until February.

Host Plants.—In order to determine the steps necessary for the control or eradication of the apple maggot, a careful study has been in progress to find which, if any, of our cultivated and wild fruits other than the apple serve as actual hosts of this insect. Each year we have collected, examined and put into recovery cages such wild fruits as lend themselves to infestation. Cultivated fruits have also been examined quite extensively. The list of fruits considered to date are: apples, wild crab (*Malus glaucescens* Rehd.), pears, peaches, plums, sweet and sour cherries, grapes, gooseberries, black currant, tomatoes, blueberries, hawthorne (*Crataegus* sp.) *Cornus* sp., cranberry (marsh), walnut, mountain ash (*Sorbus americana* Marsh), mayapple, osage orange, wild rose, high bush cranberry (*Viburnum opulus* L. variety *americanum* Ait.) and chokecherry.

Of this list hawthorn and *Cornus amomum* are the only two which have been found naturally infested with *Rhagoletis* agreeing with the description of *R. pomonella* Walsh. *R. suavis* Loew was reared from the walnut, *R. cingulata* Loew from the cherry and *Zenosema electa* Say from the wild rose hips. The fly which infests the blueberry in Maine and in Nova Scotia, and which Pickett** considers to be identical to the apple maggot, has not been bred from blueberries in Ontario.

*R. W. Dean. 1938. Experiments on Rearing Apple Maggot Adults. Journal of Economic Entomology 31 (2), April 241-244.

**A. D. Pickett. Studies on the Genus *Rhagoletis* (Tyrpetidae) with special reference to *R. pomonella* (Walsh) Canada Jour. of Res. Sect. D., Vol. 15, March 1937.

There is a good deal of doubt as to the specific identity of *Rhagoletis* flies reared from the different hosts and workers have endeavoured to solve the question by rearing, host exchange, cross-breeding and morphological studies. From the economic point of view the important question is:—Do the flies of any given host derivation infest other hosts and particularly the apple?

In the insectary flies derived from natural infestations of the apple oviposited readily in apples, pears, plums, tomatoes, cherries, *Cornus amomum,* haws, cranberries, grapes, gooseberries, black currants, may-apple and blueberries and completed their life cycle in the first seven. No flies were recovered from the other fruits but this might conceivably have been due to lack of material or to unfavourable conditions. Those reared from haws re-infested apples from which adults were again successfully reared. Those reared from plums deposited eggs in the apple but adults have not yet been recovered. With the other five fruits insufficient numbers of adults were obtained for cage study with the original host—namely the apple.

In experiments where two kinds of fruit were placed in the cage at one time, eggs were usually laid in both. With two exceptions, cherries and gooseberries, the apples received more attention than the second fruit, as shown in Table No. 2.

TABLE NO. 2.—OVIPOSITION SELECTIVITY EXPERIMENTS

Fruits	No. of egg punctures Apples	Alternate host
Golden Sweet apple and black currants	36	16
Golden Sweet apple and Shiro plum	22	18
Golden Sweet apple and Montmorency cherry	10	100
Golden Sweet apple and Red gooseberry	30	45
Golden Sweet apple and blueberries	15	15
Golden Sweet apple and blueberries	8	7
Golden Sweet apple and Shiro plum	10	5
Snow apple and grape	2	0
Green gooseberries and black currant	12	6

Of the adults reared from wild fruits those from haws oviposited and completed their life cycle in apples. The flies derived from *Cornus amomum,* about 1500, under similar treatment laid a few eggs in *Cornus* berries, but failed to puncture or deposit eggs in apples.

Cross-breeding Experiments.—During the past season male and female flies of different derivation were confined in four groups arranged as follows:

(1) 455 males (hawthorn) and 230 females (apple).
(2) 103 males (Cornus) and 131 females (apple).
(3) 244 males (apple) and 574 females (hawthorn).
(4) 82 males (hawthorn) and 31 females (Cornus).

In the first group a single pair were observed mating and eight eggs were produced. In the other three groups no mating was observed and no eggs were laid.

The Cornus Fruit Fly (*Rhagoletis sp.*).—During the past three seasons a total of 1603 adults of *Rhagoletis,* about one-third smaller than *R. pomonella* Walsh, but identical in colouration and markings, have been

reared from the dogwood, *Cornus amomum* Mill. Specimens for morphological examination were submitted to A. D. Pickett, Provincial Entomologist, Nova Scotia, who has made a special study of the apple, hawthorn and blueberry maggots. After examining the specimens and making comparison with flies derived from apple and hawthorn, Mr. Pickett stated that "Those from the apples and hawthorn are typical specimens of *pomonella* and I feel convinced those from the *Cornus* should be placed with them although there are slight differences in the male claspers. I have made the following notes in this regard: *Cornus form;* claspers slightly longer beyond the hooks than in the other forms; not so sickle shaped as the apple, hawthorn and blueberry forms, but more so than in the snowberry form. The claspers are probably somewhat more pointed than in the apple and hawthorn forms, but the tip is shaped somewhat more like the snowberry form; I feel more or less convinced that the apparent differences in the claspers in the different forms is due to the degree of cupping in the claspers themselves, I am more convinced than ever, since studying the *Cornus* forms that the slight differences found in the different forms may be accounted for by the host influence."

Bearing on the point of size of adults we have this in support of Mr. Pickett's opinion; first, that a small percentage of the flies we have reared from apples and haws are no larger than the *Cornus form,* and secondly, that when we reared the apple form in *Cornus* fruit the ensuing adults were all of the smaller size. These two facts lead us to believe that the size of the adult is determined largely by the quality and quantity of food available during its immature stages.

Our data show that the life-history of this fly is very similar to that of the apple maggot. Adults of a first generation in any current year are unknown, but flies of one and two-year life cycles have been recovered. Emergence of the spring brood occurs over a period of three to six weeks in July and August. The eggs are laid during the latter half of July and through August. The larvae mature and leave the fruit in late August and early September. They then enter the soil, transform to the pupal condition and pass the winter in this state. The flies are very sprightly and much more active than *R. pomonella* derived from apples and are not as readily seen or as easily captured. On bright days they may be seen flitting about the leaves and fruit of their host plants. Mating takes place within a few days of emergence and, although we have no definite records, we have reason to believe that under natural conditions oviposition begins about one week after emergence. Nothing is known as to the fecundity of the female. In captivity adults lived from two to thirty days. In a cross-breeding experiment the males failed to mate with females from apples. In so far as we have been able to ascertain by observation and experiment, the *Cornus* fruit fly infests only the blue-fruited species *Cornus amomum* and a species tentatively identified as *C. stricta.* No adults were recovered from collections of the white-fruited species, *C. paniculata* L'Her. For the past two seasons we have experimented with this fly in the insectary, and, under similar treatment to that afforded the apple fruit fly, have failed to induce it to oviposit in apples although some eggs were laid in the original host fruit.

Conclusions.—The results of our studies thus far lead us to believe:

(1) That the flies which now infest the apple, haws and *Cornus* have sprung from a single original species of *Rhagoletis* but that continued breeding in their respective hosts has intensified a host preference.

(2) That due to a closer relationship which exists between the apple and hawthorn and probably also to a more widespread association of these two hosts, the flies derived from these plants are less marked in their preferences and will exchange hosts under conditions of overcrowding or in the case of a failure in the fruiting of one or the other .

(3) That the hawthorn fly is definitely a menace to the apple orchard, but that as yet we have no proof that the *Cornus* fly will infest the apple.

(4) That in confinement, apple maggot flies have oviposited in a number of fruits not found to be naturally infested and that therefore insectary results are not a positive criterion as to what happens in nature. The fact that the species has been reared through a complete life cycle in some of these fruits proves that it is possible for *R. pomonella* to utilize hosts other than those commonly used.

(5) That as cross-breeding in our experiments produced either negative or negligible results, it does not occur commonly, if at all, under natural conditions.

MISCELLANEOUS NOTES ON THE CODLING MOTH

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The following miscellaneous notes on the codling moth are based on studies which are being conducted in the Niagara fruit belt, Ontario, and are presented solely for the purpose of calling attention to certain interesting trends in the behaviour of this insect.

Seasonal Studies Based on Bait Pail Records.—Bait pails have been used in an orchard at Vineland Station for eight years, 1931 to 1938, to trap adult codling moths. Since the same methods were employed each year a summary of the results should be of interest.

The orchard, which has been sprayed for codling moth (first brood only) every year, was originally about six acres in extent but at the close of 1934 was reduced by half. From 1935 to the present there have been about one hundred trees in full bearing, the rest being young trees. The varieties remaining are Ontario, McIntosh, Jonathan, Wealthy and Cranberry. There is fair protection from winds on the east and south sides.

The bait pails, except in 1931, were of glass, holding about a quart and exposing about fifteen square inches of liquid surface. Each year 20 were hung in trees with good crops, about six feet from the ground and as near the outside of the tree as possible. Ten per cent molasses in water was used and once a week the liquid was strained, the dregs discarded and fresh liquid added to maintain the level. Pails were examined daily throughout the season.

In the eight years under consideration a total of six thousand moths was taken. From the addition of the catches on the same day of each year the graph (Fig. 1) has been drawn. In order to smooth out the obscuring peaks, due to erratic catches, the system used by Dr. C. B. Williams of Rothamsted has been followed, i.e. $\gtrless \log (n+1)$ where n is the daily catch in each year. It will be noted that, taking the eight years as a whole, there may be moths in the orchard continuously from June 1 to September 13. After this date there is a gap in all years followed by a few moths up to September 21. It will also be seen that the total catch is clearly divided into two broods and that these are about equal in numbers. The dividing date between the broods may be arbitrarily put at July 24.

In any single year one of three brood arrangements may occur. (1) There may be a very small first brood and an equally insignificant

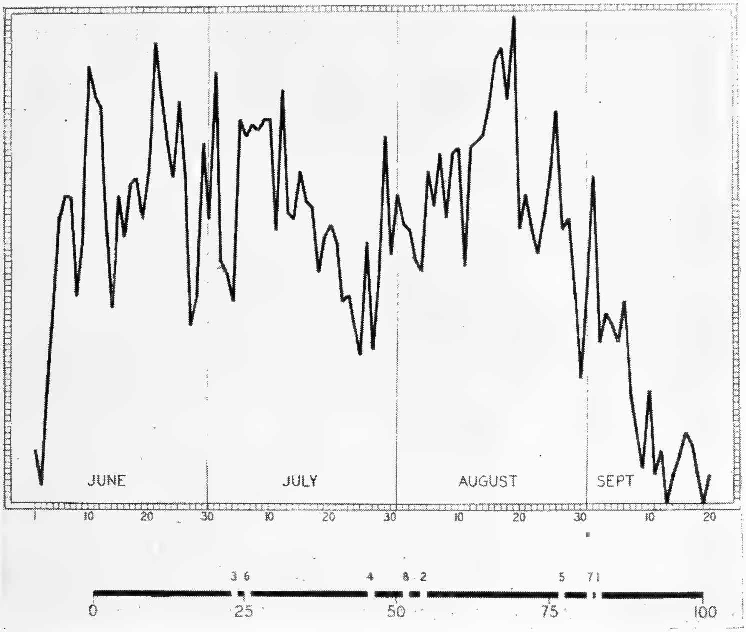

Figure. 1.—(a) Eight years, 1931 to 1938, catches of codling moths in bait pails. (b) The first brood as a percentage of the total catch is represented by gaps in the lower heavy black line. The figures above each gap indicate, omitting the first three figures, the year of occurrence.

second as happened in 1932. A variant of this occurred in 1934 when first and second broods were equally large. (2) A very high first brood may be followed by a very small second (1931), and (3) alternately a very low first followed by a high second brood (1933). No simple correlation between the weather and these brood fluctuations has been found and it is felt there must be other important factors. Were weather factors alone responsible we should not expect the fluctuations of broods to follow the regular sequence noted below. If the first brood in each year be taken as a percentage of the entire catch for that year and in each year be marked off on a line one hundred units in length (Fig. 2) a peculiar grouping is at once apparent. The eight years fall into three distinct groups with a 20 per cent. gap between them. It is unlikely that the first brood would be only 10 per cent. or lower and the second consequently 90 per cent. or over so that it is improbable that any first or second brood would fall near the ends of the 100 per cent line. With the line thus reduced at its extremities there should be more significance in the grouping along the remainder. An even more peculiar arrangement comes to light when we take the years in chronological order. Thus 1931 had a high first brood, 1932 a medium, 1933 a low, 1934 a medium, 1935 high, 1936 skipped the medium stage and went on to low, 1937 skipped back to high and 1938 regained the original cycle by reaching medium. As mentioned above weather can hardly be solely accountable for these fluctuations—they are too regular.

Broods and Heredity.—What factors are responsible for a large second brood in this locality? As a general statement it may be said that any conditions favouring an early peak of maturing larvae will also favour a large second brood because a high percentage (85-90%) of the early maturing larvae transform and give rise to a second brood. As the season advances the percentage drops steadily and fairly regularly, until mid-August when it is usually less than one per cent. In rearings over a number of years it

has been noticed that summer larvae on reaching maturity either pupate within a few days or else remain as mature larvae until winter has intervened. Now of the earliest maturing summer larvae 90 per cent. will transform and give rise to another brood and we may explain this by saying that it is the effect of temperature acting on the eggs or larvae at some time before maturity is reached. But what of the 10 per cent. that do not transform, how are we going to account for their behaviour? It occurred to the writer that heredity might have some bearing on this and the experiment described below indicates that it is in all probability a factor but its nature and influence are still far from clear.

At the end of the season of 1935 the stock of over-wintering larvae (reared material) was divided into two groups. Group 1 had remained single brooded in 1935 and group 2 had passed through two broods. These two groups have been reared separately but under similar conditions up to the present, approximately a thousand larvae being used for each lot. Table 1 summarizes the results.

TABLE 1.—CODLING MOTH BROOD INHERITANCE

PERCENTAGE IN EACH YEAR

1935	1936	1937	1938
Group 1 - A	47.0 (single) AA	94.4 - - AAA	84.2 - AAAA
		5.6 - - AAB	
	53.0 (double) AB	57.6 - - ABA	
		42.4 - - ABB	
Group 2 - B	28.9 (single) BA	87.3 - - BAA	
		12.7 - - BAB	
	71.1 (double) BB	42.0 - - BBA	
		58.0 - - BBB	36.8 - BBBB

A = single, B = double brooded in any one year. Letter groups indicate single or double brood in each consecutive year.

It will be seen that in 1936 group 1 was about equally divided between those producing one (AA) brood and those producing two (AB) broods. Group 2, however, showed a preponderance of double (BB) over single (BA) strain. As far as can be judged from other rearings conducted in 1936 the season was exceptionally favourable for a high second brood. If this was the case we should expect to find the single brooded lot in group 1 reaching a much higher percentage under conditions less favourable to a large second brood. This happened in 1937. Notice in group 1 the AA lot (single brooded now for two years) has reached the astonishing figure of 94 per cent. single brood. Even the AB lot (single brood first year, double second year) shows a tendency towards increase of single broodedness. In group 2, BB lot (double brooded in both years) the doubleness has lost ground but is still slightly over 50 per cent. In the BA lot (double first year, single second) double broodedness has almost disappeared. It was not possible to carry all these lines any further, so in 1938 only the AAA lot of group 1 and the BBB lot in group 2 were maintained. It will be noted the single brooded strain had dropped about 10 per cent. but was still a high figure. The double brooded strain dropped considerably but this may have been partly due to the rearing technique as there was a shortage of suitable apples at one period. It follows that since only about one larva can

be reared from a single apple it takes a large number of apples to rear any number of larvae, thus contamination may take place as it is difficult to be sure no larvae are introduced with the apples used for food.

Proportion of Larvae Entering Fruit at Side and Calyx.—The following figures, from a single Fameuse tree in an unsprayed orchard, are given as a record to help check up on the apparent change in habit of codling moth larvae entering fruit.

	% calyx entry	% side entry
First brood	8.3	91.7
Second brood	37.0	63.0

For first brood figures a random sample of approximately 1200 apples was picked and examined by cutting open on July 14. All the remaining apples were examined at harvest time (except drops which were examined as they fell). By subtraction of a figure based on first brood entries the entries due to second brood alone were deduced.

Caesar* states that (from work done in 1910) the average entry of first brood larvae by the calyx end was 75 per cent (on unsprayed trees). He also quotes the figures of other workers which range from 60 to 80 per cent Hall**gives figures for the years 1923-1928 which average for calyx entries 42.8 per cent first brood, 18.1 per cent second brood (unsprayed trees). The range in these years was from 28 to 55 per cent for first and 10 to 27 per cent. for second brood. There would thus appear to be some grounds for the belief, held by many, that there has been an increase in the proportion of side entries in recent years.

*Bull. 187, Ontario Agricultural College.

**59th An. Rep. Ent. Soc. Ont., 1929

ON THE BIOLOGY OF THE CODLING MOTH IN QUEBEC

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The results obtained from our researches of 1937, on the biology of *Carpocapsa pomonella* L. have disclosed the fact that the life-history of this insect in Quebec is much different from what was previously supposed to be the case. Therefore, it was decided with the agreement of our chiefs Dr. Maheux and Mr. Gauthier, that it would be interesting from the standpoint of entomological science as well as from the practical point of view of our apple growers to continue our research work in 1938 in order to obtain more exact results and to better justify the new recommendations which we would have to make for the control of one of our most important orchard pests.

Our studies of this insect were carried on both in the insectary and in the orchard. In the insectary we tried to reproduce as closely as possible the natural environmental conditions of the insect and to rear it during all the period of its activities in the orchard.

COMPARATIVE RESULTS OF REARING IN INSECTARY FOR 1937-1938

TABLE 1.—SUMMARY OF OVERWINTERING GENERATION DEVELOPMENT IN THE SPRING 1937-1938

(*Codling moth*)

		1937	1938
Time of moth emergence (in orchard)	First Maximum Last	May 30th June 25th July 31st	June 1st July 5th July 29th
Pre-oviposition in days	Average Minimum Maximum	2.75 1. 11.	3.456 2. 12.
Number of days from moth emergence to maximum oviposition	Average Minimum Maximum	5.77 1. 16.	8.143 2. 15.
Number of days of oviposition per female moth	Average Minimum Maximum	17.39 1. 14.	11.245 1. 18.
Number of days from emergence to last oviposition	Average Minimum Maximum	11.28 4. 24.	15.263 8. 23.
Number of eggs per female moth	Average	5.62	43.869
Life of male moths in days	Average Minimum Maximum	9.02 1. 24.	13.1 2. 26.
Life of female moths in days	Average Minimum Maximum	9.90 2. 25.	12.92 2. 25.

TABLE II.—SUMMARY OF FIRST GENERATION DEVELOPMENT 1937-1938 IN INSECTARY

(Codling moth)

		1937	1938
Time of egg deposition	First Maximum Last	June 10th June 17th July 30th	June 8th July 9th August 4th
Length of incubation period in days	Average Minimum Maximum	8.13 5. 14.	8.08 5. 15.
Time of larval hatching	First Maximum Last	June 19th July 6th August 7th	June 18th July 14th August 4th
Length of larval feeding period in days	Average Minimum Maximum	22.72 16. 43.	23.86 14. 45.
Time of pupation	First Maximum Last	July 17th July 25th Sept. 1st	July 11th July 18, 19, 22nd August 8th
Length of pupal period in days	Average Minimum Maximum	15.55 10. 25.	17.26 10. 32.
Time of moth emergence	First Maximum Last	July 29th August 9th August 20th	July 27th August 3, 12 August 31st
Pre-oviposition period in days	Average Minimum Maximum	3.83 1. 10.	2. 1. 8.
Number of days from moth emergence to maximum oviposition	Average Minimum Maximum	5.88 3. 11.	3.57 1. 9.
Number of days of oviposition per female moth	Average Minimum Maximum	6.27 1. 14.	7.66 1. 15.
Number of days from emergence to last oviposition	Average Minimum Maximum	10.61 6. 19.	10.37 3. 16.
Number of eggs per female moth	Average	14.59	50.42
Life of male moths in days	Average Minimum Maximum	14.23 2. 34.	10.61 1. 25.
Life of female moths in days	Average Minimum Maximum	17.73 2. 36.	10.61 1. 24.
Life cycle in days from 1st oviposition to moth emergence	Average Minimum Maximum	50.23 33. 92.	49.20 29. 92.

From our records of emergence of moths in the insectary, 48.987 per cent. in 1937, and 16.89 per cent. in 1938, of larvae of the first generation transformed to form a partial second generation.

TABLE III.—SUMMARY OF SECOND GENERATION DEVELOPMENT IN INSECTARY 1937-1938

(*Codling moth*)

		1937	1938
Time of egg deposition	First Maximum Last	August 2nd August 7th Sept. 5th	July 29th August 15th Sept. 2nd
Length of incubation period in days	Average Minimum Maximum	6.67 5.06 7.93	7.63 6. 11.
Time of hatching of larvae	First Maximum Last	August 9th August 16th August 29th	August 5th August 15th August 31st
Length of larval feeding period in days	Average Minimum Maximum	23.58 27. 21.	29.46 20. 36.

RESEARCH IN ORCHARD

Our observations in the orchard were based on the use of band-traps and bait-traps. Fifty corrugated paper bands, 4 inches wide, were fixed on 50 well scraped apple trees. The number of individuals collected, at each time that the bands were examined, was recorded for 1937 under two different headings, larvae and pupae, according to stage they were in when the bands were examined.

The first larvae and pupae were thus collected under the bands July the 16th for 1937 and July the 19th for 1938. The maximum captures were July the 27th, August the 12th for 1937, August the 13th and 24th, 1938. The last captures were September the 7th, 1937 and September the 16th, 1938.

Each group of individuals thus collected was placed in a different cage, in order to allow the larvae to complete their cycle of development and to establish moth emergence records for each group respectively. At the end of this paper a comparative table of these emergences is included.

The percentage of moths that emerged, in regard to the number of the first generation larvae in cages, was 29.97% in 1937 and 15.73% in 1938.

Bait-traps:

a) Spring brood moths 1937 and 1938

The first moths of the overwintering generation were captured on May the 29th in 1937, June the 1st in 1938 and the last ones for that generation July the 31st in 1937, July the 29th in 1938. The highest peaks were June the 25th in 1937, July the 5th in 1938.

b) Moths of first generation 1937 and 1938

The first moths were captured August the 4th in 1937, July the 31st in 1938 and the last ones September the 2nd in 1937, September the 11th in 1938. The highest peaks were August the 16th and the 18th in 1937 and August the 5th and the 16th in 1938.

c) TABLE IV.—TOTAL CAPTURES OF CODLING MOTH IN BAIT-TRAPS 1937 - 1938

Months	Number of days		Number of moths		Number of males		Number of females	
	1937-1938		1937-38 Spring		1937-1938		1937-38	
May	3	0	5	0	2	0	3	0
June	30	30	356	516	199	328	157	188
July	31	31	602	534	327	347	275	187
Total:	64	61	963	1050	528	675	435	375
			First generation					
August	31	31	273	185	138	103	135	82
September	2	11	7	6	2	3	5	3
Total:	33	42	280	191	140	106	140	85
Final Amt.	97	103	1243	1241	668	781	575	460

d) Now if we compare the moth emergence of the first generation as recorded in the orchard by means of bait-traps, in outside cages and in insectary for the last two years, we have the following dates:

TABLE V

	ORCHARD 1937	ORCHARD 1938	CAGES 1937	CAGES 1938	INSECTARY 1937	INSECTARY 1938
First	Aug. 4	July 31	July 20	July 30	July 30	July 27
Maximum	Aug. 16-18	Aug. 5-16	Aug. 10	Aug. 20	Aug. 3-9	Aug. 3-12
Last	Sept. 2	Sept. 11	Aug. 20	Aug. 31	Aug. 18	Aug. 31

CONCLUSION

We hope that the results of these studies will dissipate any remaining doubts as to the existence of a partial second generation of codling moths in Quebec. However, we think there will still be advantages in continuing this work on the biology of the codling moth in Quebec for a few years in order to obtain more representative results. Meanwhile we believe that the results already obtained could be used from now on as a source of information to the spray service regarding the time of spray applications for the control of the codling moth.

BIOLOGICAL CONTROL OF THE ORIENTAL FRUIT MOTH *LASPEYRESIA MOLESTA* BUSCK IN ONTARIO:

A REVIEW OF TEN YEARS' WORK

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The Oriental fruit moth was introduced into this continent about 1913, and since that time has spread to all the peach growing areas of the eastern United States and Canada. It became established in Ontario shortly after 1920 and in 1925 was discovered causing considerable damage to peaches at St. Davids in the eastern end of the Niagara Peninsula. By 1927 the outbreak had reached such serious proportions that loss of the entire peach crop at St. Davids was threatened, and it had also shown considerable spread in all directions. This rapid population expansion continued until, in the fall of 1929, many orchards in the St. Davids - Niagara-

on-the-Lake district were suffering over 50 per cent. injury, with damage in one orchard at Niagara-on-the-Lake as high as 90 per cent. The general situation in the fall of 1929 was very discouraging.

From 1930 the spread of the moth became general throughout the Niagara Peninsula, reaching a fairly constant degree of infestation by 1935. In subsequent years the combined activity of the introduced species of *Macrocentrus* and the native parasites, which were of considerable value in some years, was sufficient to maintain a fairly high degree of control and to effect a general, progressive reduction in yearly damage.

The history of the moth infestation in Western Ontario has been much the same as that in the Niagara Peninsula, except that the years of severe injury occurred much later. It was first discovered at Olinda, in Essex County, at about the same date as it appeared at St. Davids. The infestation developed much more slowly and spread was less rapid, probably due in part to the scattered location of the peach orchards. Injury was noticeable in 1930 and 1931, and considerable damage occurred at Olinda and Cedar Springs in 1935. In 1937 the population had reached such proportions as to render much of the fruit unsalable in the areas of older infestation. The same trend continued in 1938, and the severe injury caused by the first generation larvae indicated another year of heavy damage. However, biological control factors became active and by the end of the season the fruit crop was fairly free of injury. Reduction in this area was caused by the combined activity of *Macrocentrus ancylivorus* Rohwer, which had been heavily colonized since 1935, and *Glypta rufiscutellaris* Cress.

Studies conducted in 1927, on the biology of the newly introduced pest in Ontario, showed it to be practically free of attack by indigenous parasite species. In the areas of older infestation, such as New Jersey, parasites were responsible for a high mortality, although attempts to control the insect by the application of dusts and sprays had been unsatisfactory. In view of this information an immediate programme of parasite introductions was decided upon. The egg parasite *Trichogramma evanescens* Wesm. was being propagated at the Parasite Laboratory in connection with biological control of the European corn borer, and was the first species used in this work against the fruit moth. During the summer of 1928 the first experimental liberations of *T. evanescens* were made. Encouraging results were obtained and in the following years the work was greatly expanded. Colonizations of this species were continued until 1933 when field conditions warranted their discontinuance.

The parasite work was further expanded in 1929 when, through the courtesy of the Chief of the United States Bureau of Entomology, arrangements were made by the Dominion Entomologist which resulted in the collection of *Macrocentrus ancylivorus* Rohwer in southern New Jersey and its colonization in the Niagara Peninsula. *Macrocentrus* showed a remarkable adaptation to Ontario conditions and rapidly became a factor of control. Work in subsequent years was centred around the dispersal of this parasite throughout the province, as well as the study of the ecological factors affecting its activity and relation to native parasite species. A more extensive study of the native species of parasites attacking the moth also was undertaken.

The parasite studies were extended to Western Ontario by releases of *Macrocentrus* as early as 1930 and 1931. Recovery collections at the colonization points gave promising recoveries of this species immediately after the releases, but in succeeding years it appeared that the colonies had

died out. No further parasites were placed in this area until 1935, when the severity of the infestation indicated the desirability of attempting the establishment of large colonies of *Macrocentrus.* In the following years all the available parasites were released in Western Ontario.

Trichogramma spp.—Orchard colonizations of *Trichogramma evanescens* Wesm. were begun in July, 1928 (9). These early releases were made with 75,000 adult parasites in a series of experiments. The results indicated that a measure of control might be expected from large scale releases, and plans were made for continuing the work. From the beginning the studies were somewhat complicated by the appearance of a native strain of *Trichogramma,* later identified as *T. embryophagus* (Hartig.), in the experimental blocks.

A much larger number of *Trichogramma* was available for the work in the summer of 1929 (12, 20, and 21), and an important change was made in the technique of liberation. The parasitized laboratory host eggs were fastened into the colonization trees just previous to parasite emergence, which allowed the parasite adults to make their way naturally into the foliage. The parasitized host eggs were sealed into waxed paper drinking cones at the laboratory and were fastened into the tree by the use of a string run through the apex of the cone. A small opening in the top of the cone allowed the parasites free access to the tree and the cone protected the host eggs from the vicissitudes of weather and predators. The 1929 experiments showed that in heavily infested orchards a fairly heavy percentage of egg parasitism could be obtained from releases made during the presence of second generation Oriental fruit moth eggs. In turn, the parasitism of second generation eggs provided a large reservoir of parasites in the orchard, to destroy third generation eggs, and thus protect the fruit from the feeding of the larvae of this generation.

The work with *Trichogramma* was carried out along the same general lines in the following years (16). It was found more satisfactory to place 10,000 parasitized host eggs of four different developmental ages in the cones. This provided a continuous parasite emergence covering from six to ten days, depending upon the orchard temperatures, and greatly facilitated the maintenance of a continuous supply of parasites in the colonization trees during the abundance of host eggs. For convenience, one acre of orchard was considered a unit and releases varying between 20,000 and 1,000,000 parasites per unit were tried.

The amount of control secured from the releases of *Trichogramma* in heavily infested orchards resulted in a marked reduction in fruit damage. This was particularly true in the early years of the study before the intensity of the moth infestation began to show a decline. On the basis of the releases made during the course of six growing seasons, it seems safe to assume that the colonization of this parasite is a useful immediate means of reducing the damage from a heavy infestation of the Oriental fruit moth.

During the course of the work a total of 29,870,000 *Trichogramma,* consisting of three species, was released. The work was begun with *T. evanescens* Wesm., a gray strain the initial stock of which was secured from the southern United States. When it was found that a yellow strain, *T. embryophagus* (Hartig), appeared naturally in the orchards, it was introduced into the laboratory breeding and toward the latter part of the work was used exclusively. One large heavily infested block of peaches was treated with 5,000,000 *T. semblidis* (Aur.). The liberations with *evanescens* gave good parasitism following the releases, but failed to per-

sist in the orchards. Collections of *Trichogramma* made the following spring after large releases of *evanescens* always yielded *embryophagus*. *T. semblidis* appeared entirely unsuited to orchard conditions, and recovery collections made one month after the large release of this species failed to show its presence in the orchard.

While it was early recognized that the use of *Trichogramma* as an Oriental fruit moth control, has several limiting factors, the urgent need for at least partial control appeared to justify its continued use, until a more satisfactory method had been secured. The experiments were confused from the beginning by the appearance of varying numbers of native *Trichogramma* in the orchards. Accurate figures for egg parasitism were difficult to secure, since the shells of hatched moth eggs tended to remain on the foliage and swell the numbers of what appeared to be recently hatched eggs. During dry seasons these shells remained on the leaves for several weeks. Lastly, the amount of egg parasitism secured from a release was more dependent upon the intensity of host infestation than upon the numbers of parasites released. In the presence of a large moth infestation, a small number of *Trichogramma* was sufficient to build up a large population, while in orchards of low infestation large releases made little appreciable increase in egg parasitism.

Macrocentrus ancylivorus Rohwer.—The almost complete absence of larval parasites attacking the Oriental fruit moth, following its discovery in Ontario, led to an investigation of the possibilities of securing suitable species from foreign sources. The most promising parasite appeared to be *Macrocentrus ancylivorus* Rohwer, a hymenopterous larval parasite (10), which was producing a fairly satisfactory control in Southern New Jersey. Through the courtesy of the United States Bureau of Entomology arrangements were made to collect host larvae, parasitized by *Macrocentrus*, during the spring of 1929 in the Moorestown district of New Jersey. Accommodations for handling the daily collections were kindly furnished by the Japanese Beetle Laboratory. Collections of both the Oriental fruit moth and another heavily parasitized host insect, the strawberry leaf roller (*Ancylis comptana* Froehl.) were made. In early June this material was transported to the quarantine rooms of the Dominion Parasite Laboratory at Belleville, where emergence was taken.

The collections provided 2,350 *Macrocentrus* for colonization, and these were released at two points, St. Davids and Niagara-on-the-Lake in the area of heavy infestation in the eastern end of the Niagara Peninsula (13). Establishment was immediate and from the final generation of the moth in the same season, 380 recoveries were secured and the parasite had dispersed over a known area of 35 square miles. The effect of its activity was apparent in cleaner fruit in the colonization orchards the first year.

Parasite collections were again made in Southern New Jersey in 1930, and an additional 8,829 *Macrocentrus* were secured for the work in Ontario (12, 13 and 14). This number was further increased by 2,134 parasites obtained by laboratory breeding and collections from the orchards where *Macrocentrus* was already established. The bulk of this material was also colonized in the heavily infested orchards in the St. Davids, Queenston, and Niagara-on-the-Lake districts. One small colony was placed at Fonthill, and two in Western Ontario at Cedar Springs and Olinda. As in the previous years, the parasite readily attacked the Oriental fruit moth at the new colonization points and, with the exception of Western Ontario, rapidly increased in numbers.

No further *Macrocentrus* collections were made in southern New Jersey and parasites for subsequent distribution were obtained from recovery collections made in the areas of *Macrocentrus* establishment, and from laboratory breeding. The following numbers of the parasite were released during the years under review:

1929	Niagara Peninsula	2,350	New Jersey material
1930	" "	10,573	New Jersey material and recovery collections
1931	" "	3,628	Recovery collections and breeding
1932	" "	4,251	"
1933	" "	1,331	"
1934	" "	4,090	
		26,223	
1930	Western Ontario	490	"
1931	" "	118	"
1935	" "	16,247	"
1936	" "	10,948	"
1937	" "	5,527	"
1938	" "	2,806	
		36,136	
Total releases for Ontario		62,359	

The time of release of *Macrocentrus* had a marked influence on its establishment and later increase. Parasites released against the first generation larvae, in June, were advantageously placed to increase on the twig feeding first and second generations and were, therefore, able to effect a considerable reduction of the host population before the development of the third generation larvae which attack the fruit. Liberations against the second generation, in July, were adversely affected by more unsatisfactory weather conditions and the absence of the opportunity to increase on the first generation of the host. These factors inhibited the increase of the parasite previous to the occurrence of the third generation of the host. From the standpoint of economy and control, it was found that releases of *Macrocentrus* made early in the season were much more satisfactory than those made against second generation larvae.

The parasite finds only a small percentage of larvae, accessible to attack, in the third generation and consequently the numbers of parasites going into hibernation are greatly reduced. In some areas the spring emergence of *Macrocentrus* is augmented by a varying number overwintering in the strawberry leaf roller, or in third generation Oriental fruit moth larvae feeding in apple plantings near peach orchards. Studies on the reproductive capacity of this parasite under orchard conditions suggest a high fecundity which is able to offset the winter mortality and produce high first generation parasitism.

A study of the establishment and increase of *Macrocentrus* was commenced, following the initial introduction of 1929 ,by collecting infested twigs and rearing the larvae to maturity. Collections from 1929 to 1932 were made at, and adjacent to, the colonization points, and were limited in size so that *Macrocentrus* would not be adversely affected by removing large numbers from the liberation orchards. During 1932 some 30 points were chosen in the peach growing sections of the Niagara Peninsula, and regular larval collections were made. Two series of collections were secured; (1) in a certain number of orchards collections were made weekly

and (2) at the majority of the points the collections were made only at the periods of maximum abundance of the fruit moth larvae of the first and second generations. These two types of collection supplemented each other and, in general, gave very similar results.

Only small samples of the third generation have been secured, due to the difficulty of collection, which involves cutting the fruit to secure the larvae. The records we have indicate a rather low parasitism of from two to five per cent. of the larvae from this source.

The number of *Macrocentrus* recovered from collections of the first, second and third generations of the host, during the period from 1929 to 1938, are presented in the following table:

TABLE 6.—NIAGARA PENINSULA

	First generation		Second generation		Third generation
1929	20 individuals		21 individuals		380 individuals
1930	281 ”		771 ”		191 ”
1931	667 ”		551 ”		no collections
1932	497	8.7%	457	10.7%	27 individuals
1933	1146	27.8	549	28.2	29 ”
1934	329	12.3	628	41.7	no collections
1935	555	30.8	1612	74.4	”
1936	702	41.5	1039	54.5	”
1937	1083	42.8	1842	71.5	”
1938	839	44.6	882	56.1	”

The following table shows the increase in *Macrocentrus* parasitism in the Niagara Peninsula during the years when the parasite was becoming distributed in that area. Vineland was chosen as the dividing point of the district and records from this place were included with those of the eastern half of the Peninsula. The general parasite establishment indicated by the figures for 1936 has remained fairly constant in the succeeding years.

TABLE 2.—PARASITISM BY MACROCENTRUS ANCYLIVORUS OBTAINED FROM COLLECTIONS OF INFESTED TWIGS

	First generation		Second generation	
Year	East of Vineland	West of Vineland	East of Vineland	West of Vineland
1932	8.1%	0.0%	15.7%	4.1%
1933	32.7	3.8	46.8	6.2
1934	14.5	5.4	54.4	15.2
1935	38.6	14.2	79.6	65.0
1936	42.8	42.0	56.3	54.0
1937	44.5	37.7	70.7	69.8
1938	44.9	43.1	54.6	58.3

During the past three years the Oriental fruit moth work in the Niagara district has consisted mainly in taking observational records. The course of the moth infestation and activity of its parasitic fauna has been followed, as in previous years, by a combination of weekly and generation recovery collections, and surveys of the extent of twig injury at the conclusion of the first and second generation larval activity.

The averages of the 42 points used for the survey records in the Niagara Peninsula are presented in the following table. It will be seen that there was a close correlation between the increase in *Macrocentrus* parasitism and the decrease in twig injury. The figures presented are expressed by percentages:

TABLE 3.—TWIG INFESTATION AS SHOWN BY SURVEYS
NIAGARA PENINSULA

Year	First generation	Second generation
1932		29.9%
1933	9.3%	18.3
1934	9.8	21.9
1935	2.4	13.8
1936	1.5	2.6
1937	2.1	3.4
1938	.9	2.5

The records secured from the examination of maturing fruit show the same general reduction in moth infestation. These figures show the heaviest damage to fruit at St. Davids in 1927, when injury was 64.0 per cent. and Niagara-on-the-Lake, in 1928 when injury reached 73.7 per cent. In the year following the establishment of *Macrocentrus* at each of these points a noticeable decline was apparent which continued until in recent years a fruit damage of less than two per cent. is the general rule. In 1938, 12 of the large canning factories packing peaches were circularized regarding the amount of the moth found in the peaches purchased for canning. Only one packer claimed to have more than one percent., while the others reported infestations ranging from a trace to one per cent.

The biological control work in Western Ontario was developed much more slowly and was due to the pressing need for work in Niagara, as previously stated. By 1929 damage was very noticeable at Cedar Springs, and Olinda, but until 1936 and 1937 the severity of the attack did not materially increase, although its distribution throughout all the peach growing areas became quite general. Small colonies of *Macroncentrus* were released at Cedar Springs and Olinda in 1930, and at Olinda only in 1931. These liberations were extremely small and the colonies showed no increase, so that by 1933 no further recoveries were secured at the original release points.

From 1935 all available *Macrocentrus* were liberated in Western Ontario. In 1935 and 1936 practically all the parasites were released at Olinda and Cedar Springs. A programme of dispersion was carried out in 1937 and 1938 and *Macrocentrus* was colonized in all the peach growing districts. The parasite became established throughout the entire area, and in the districts of older colonization soon became an important factor of control.

TABLE 4.—INCREASE OF *MACROCENTRUS* IN DISTRICTS OF HEAVY MOTH INFESTATION

	First generation	Second generation
	1936	
Olinda	20.0	42.8
Cedar Springs	45.0	40.8
	1937	
Olinda	20.8	52.8
Cedar Springs		19.4
Leamington	32.1	15.4
	1938	
Olinda	69.2	81.8
Cedar Springs	61.5	88.8
Leamington	29.3	62.1

The activity of *Macrocentrus* was reflected in a definite drop in fruit damage in 1938, as compared to the preceding year, when at several points much fruit was rendered unsalable.

Native Parasites and Predators.—Orchard observations made on Oriental fruit moth eggs and larvae during the early years of the studies, showed a low mortality resulting from the activity of native parasites and predators. Native *Trichogramma* have been present in varying degrees of intensity and, in some orchards, have caused a high mortality to moth eggs. In 1930 chrysopid larvae appeared in the orchards in large numbers and fed extensively on peach moth eggs and larvae (1, 3 and 4). They still were present in considerable numbers in 1931 but, thereafter, became less numerous. In 1931 there was a phenomenal increase in the activity of *Glypta rufiscutellaris* Cress. on second generation larvae. In the following years *Glypta* remained the most abundant species of native parasite but, unfortunately, from the standpoint of moth control, it is not dependable, since it varies in abundance from year to year and of recent years has been less abundant than formerly. This seasonal abundance of *Glypta* seems dependant upon the status of its native alternative hosts (5 and 7), and its decline in value in recent years as an Oriental fruit moth parasite may be, in part, due to its inability to compete with *Macrocentrus* for host material. As *Macrocentrus* became more plentiful, *Glypta* became increasingly less important. Another serious disadvantage of *Glypta* as a controlling agency is its late seasonal appearance in peach orchards. *Macrocentrus* has completed a generation on the moth before *Glypta* begins its attack. *Macrocentrus* synchronizes its activity with that of the moth from early spring until hibernation, and completes three full generations. *Glypta* appears in late July or August and completes but one generation on this host. In all 44 native species (see list) have been found parasitizing some stage of the Oriental fruit moth and, of these, *Glypta* is responsible for practically all the moth mortality. Two other native parasites, *Cremastus minor* Cush. and *Dioctes obliteratus* (Cress.) are active in some years, but cannot be considered of any constant economic value.

TABLE 5.—LARVAL MORTALITY CAUSED BY NATIVE PARASITES AND *MACROCENTRUS* IN THE NIAGARA PENINSULA

	First generation			Second generation		
Year	Native	*Macrocentrus*	Total	Native	*Macrocentrus*	Total
1929	1.5			3.9		
1930	3.6			11.5		
1931	8.8			67.3		
1932	6.1	8.7	14.8	71.1	10.7	81.8
1933	3.7	27.8	31.5	40.0	28.2	68.2
1934	3.9	12.3	16.2	37.0	41.7	78.7
1935	2.7	30.8	33.5	15.8	74.4	90.2
1936	3.1	41.5	44.6	20.4	54.5	74.9
1937	4.1	42.8	46.9	17.5	71.5	89.0
1938	17.8	44.6	62.4	22.4	56.1	78.5

The third generation of the moth is relatively free from parasite attack. *Trichogramma* reaches its greatest abundance in peach orchards during the presence of third generation eggs, but only in the occasional orchard is it of any importance in control. The feeding habits of the larvae of this generation in the fruit render their attack by the larval parasites very difficult and fewer recoveries are secured.

Observations made on the parasites attacking the spin-ups and pupae showed these stages practically free from parasite attack ,but susceptible to a fairly high mortality from the activity of predaceous bugs, spiders, and ants. Because of the difficulty of securing representative samples of these stages, due to the scarcity of finding material, suitable studies could not be made.

List of Parasites of the Oriental Fruit Moth Secured in Ontario.—*Actia interrupta* Curran. *Aenoplex betulaecola* Ash., *Anachaetapsis tortiricus* Coq., *Angitia* sp., *Apanteles* sp., *Ascogaster carpocapsae* Vier., *Atrometus clareipes* (Darius), *Bassus cinctus* Cress., *Calliephialtes grapholithae* (Cress.), *Campoplex* sp., *Cremastus forbesii* Weed, *Cremastus minor*, Cush.,*Cremastus sp.* near *epagager* Cush., *Cremastus* sp. near *plesius* Cush., *Cremastus* sp., *Cremastus tortricidis* Cush., *Dibrachys cavus* Wlk. (primary and secondary), *Dioctes obliteratus* (Cress.), *Elephantacera greeni* Town., *Epiurus indagator* Walsh, *Epiurus sp.*, *Ephialtes aegmalis* (Prov.), *Eubadizon pleuralis* (Cress.), *Eubadizon* sp., *Glypta rufiscutellaris* Cress., *Glypta varipes* Cress., *Glypta* sp., *Hemiteles tenellus* (Say) (secondary), *Lixophaga parua* Tns., *Lixophaga plumbea* Ald., *Macrocentrus ancylivorus* Rohwer, *Macrocentrus delicatus* Cress., *Macrocentrus instabilis* Mues., *Macrocentrus laspeyresia* Mues., *Meteorus* sp., *Meteorus trachynotus* Vier., *Microbracon mellitor* Say, *Microbracon palitinentrio* (Cush.) *Microbracon* sp., *Microgaster ecdytolophae* Mues., *Nemorilla maculosa* Nig., *Pristomerus ocellatus* Cush., *Trichogramma embryophagus* (Hartig), *Tromera* sp., *Phorocera erecta* Coq.

Summary.—The Oriental fruit moth, which in the early years of this study represented a definite threat to the future of the peach growing industry of Ontario, has receded in importance and now appears to be under satisfactory control. Even in Western Ontario, where there was a serious outbreak as late as 1937, the pest has now shown a marked reduction.

The turning point in the increase of the moth took place in 1930 following the introduction of *Macrocentrus*, together with a notable increase in the activity of native parasites and predators which reduced the population of the pest, and gave an opportunity for *Macrocentrus ancylivorus* Rohwer, the introduced larval parasite, to become proportionately more numerous and, thereafter, it has represented by far the most important factor contributing to Oriental Fruit Moth control. This parasite has displayed marked adaptability to the climatic conditions of Ontario and wherever it has become definitely established, synchronizes its life cycle with that of the moth. Only one native parasite, *Glypta rufiscutellaris* Cress., has been of any importance in reducing the numbers of the pest. This parasite is not consistent in its yearly abundance, but fortunately *Macrocentrus* does not suffer in competition with it, and when present, *Glypta* supplements *Macrocentrus* as a control agency.

The present status of the Oriental fruit moth in relation to its natural enemies indicates that this pest has approached a condition of environmental balance. Periodic increases of the moth population in orchards, and even districts may be expected but, in general, its parasitic and predaceous enemies may be expected to hold it in effective check.

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A STRAIN OF *TRICHOGRAMMA SEMBLIDIS* AUS. FROM PRINCE EDWARD COUNTY, ONTARIO, CANADA

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On July 1, 1931, a dark strain of *Trichogramma*, containing a high percentage of dimorphic wingless males, was found in abundance attacking the eggs of *Sialis infumata* Newm., along the shore of Lake Ontario. The host eggs were abundant on willow leaves suspended over the surface of the lake. Several millions of parasitized *Sialis* eggs were collected and

transferred to peach orchards in the Niagara District, where the Oriental fruit moth (*Laspeyresia molesta* Busck.) was present in outbreak form (van Steenburgh, 1934).

Several times during the intervening years the question of the identity of this species of *Trichogramma* has arisen. Flanders referred to this species as *semblidis* in his discussion on the habitat selection of *Trichogramma*. Later Salt carried out a series of experiments on a similar strain found attacking *Sialis lutaria* Linn. eggs in England. His work showed that in the English species the wingless form of male was reared exclusively from field collected *Sialis* eggs, while this same strain in the laboratory, reared on lepidopterous eggs, produced only winged males.

Dr. Salt kindly furnished this laboratory with mounted specimens of the dimorphic males and normal females. These were compared with the Ontario strain and were found to be morphologically similar. Field collections of the Ontario strain from *Sialis infumata* Newm. eggs and laboratory rearing of the species on several lepidopterous hosts demonstrated the presence of both types of males in the normal and artificial habitats. There was a definite trend toward a preponderance of wingless males in the field and the opposite trend under laboratory conditions.

The percentage of the forms found in the field and the laboratory are shown in the following table:

TABLE 1.—NUMBERS AND PERCENTAGES OF *TRICHOGRAMMA* FORMS FROM VARIOUS HOSTS

	Numbers			Percentages	
	Males	Wingless Males	Females	Wingless Males	Females
Sialis infumata Newm	9	509	530	98.2	50.6
Ephestia kuehniella Zell.	331	124	436	27.2	48.9
Cydia pomonella Linn.	147	22	223	13.0	59.4
Cydia molesta Busck (1 day)	581	185	877	24.2	53.4
Cydia molesta Busck (2 day)	213	52	491	19.6	64.9
Pyrausta nubilalis Hbn.	41	4	55	8.8	55.0

The trend in the rearing results showed fewer wingless males when the larger host eggs were used. When eggs of *Pyrausta nubilalis* Hbn. were offered to the parasites very incomplete parasitism was secured and in four breeding lots, when this host was used, the eggs were refused completely. The age of the host eggs used did not affect materially the percentage of the types of males secured.

The moisture content of the habitat of *semblidis* is much more critical than with *embryophagus* or *evanescens*. Reducing the humidity in the laboratory breeding containers did not seem to vary the types of males produced. In cases where the relative humidity was reduced much below the saturation point emergence did not take place.

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FURTHER NOTES ON CORN BORER RESISTANCE IN HYBRID CORN; WITH A BRIEF STATEMENT OF THE INFESTATION SITUATION IN ONTARIO IN 1938

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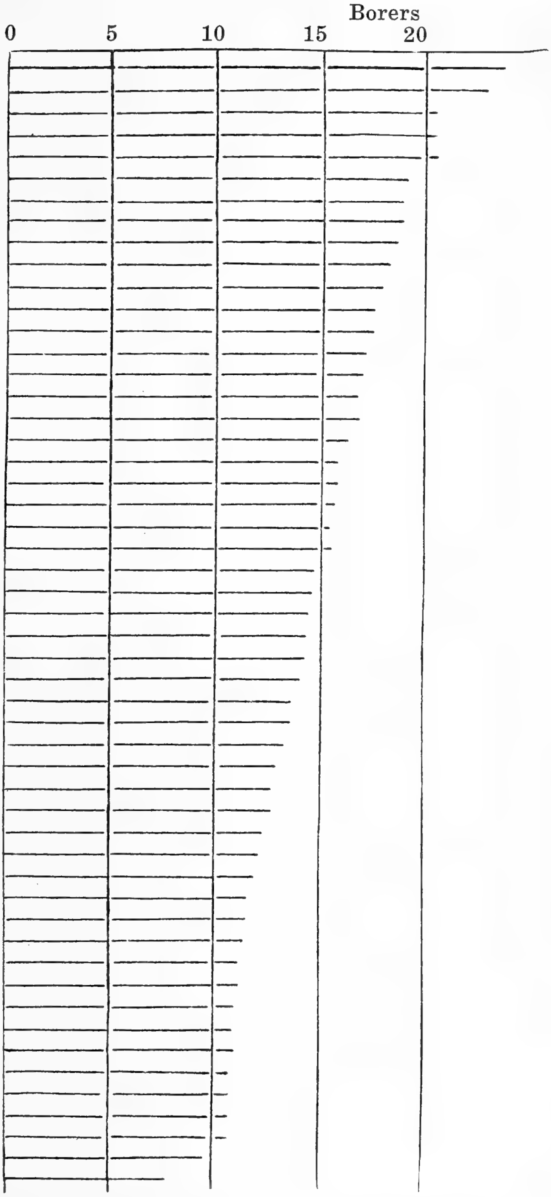
At last year's meeting of the Entomological Society of Ontario, the writer reported the results which had been obtained in tests for corn borer resistance in corn hybrids versus popular standard varieties, co-operatively conducted by the Departments of Entomology and Field Husbandry at Guelph, Ridgetown and Woodslea. In 1938, 17 standard varieties and 40 hybrids were used in these tests, and examinations were made by dissections of all these, with the exception of five which were clearly so unsuitable for this province that they were discarded. This number of plots is much larger than last year, and, by reason of the increase, it was possible this season to collect data on the entomological aspects of this problem from the Guelph and Ridgetown replicates only. As in last year's experiments, the borer populations were determined by dissections of 10 stalks taken at random from the north row of each plot. At Ridgetown, two of the four replicates were sampled in this manner, and at Guelph all four replicates were sampled with two counts being made in the first two replicates, thus making six separate counts for each variety and hybrid at Guelph. In addition to the borer populations which are reported as averages of all the counts, it was considered necessary to include again this year the percentage of broken or bent stalks.

CHART 1.—AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, GUELPH, 1938

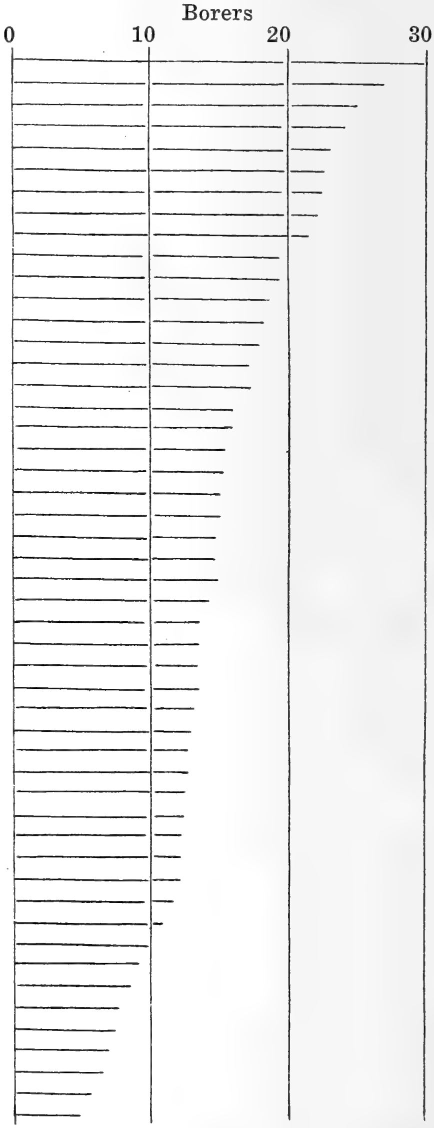
	No. Borers
Golden Glow Sd. Stuart	23.00
Minhybrid 401	22.30
Longfellow Sd. Maynard	20.83
Hybrid K 35 Wooster, Ohio	20.30
Wisconsin No. 7 Sd.	20.30
Bailey Sd.	19.30
Northrup King Kx 206D	19.00
Minhybrid 402	19.00
West Branch Sweepstakes Sd.	18.70
Wisconsin 680	18.00
Canada Golden Glow Sd.	17.66
Compton's Early Sd.	17.57
29-3 XX Cornell Univ.	17.57
Wisconsin 525	17.42
Hybrid 493 De Kalb	17.33
Northrup King K x M 700-A2	16.85
Funk's Hybrid G-15	16.66
Excelsior, Vaughan Seed	16.43
Northrup King KxR 421 T	16.30
Wisconsin 570	16.16
White Cap Yellow Dent Sd.	16.00
Wisconsin 531	15.50
Northrup King KxR 425M	15.43
Minhybrid 301	14.80
Salzer's North Dakota Sd.	14.66
Northrup King KxE 612-E2	14.50
Wisconsin 655	14.50
Wisconsin 606	14.30
Hybrid K 23 Wooster, Ohio	14.00
Hybrid 436 Wooster, Ohio	13.50
Golden Glow, Smith Sd.	13.50
Carter's Crossed Corn	13.17
Wisconsin 645	13.00
Hybrid 202 De Kalb	12.66
Funk's Hybrid G-7	12.66
Northrup King KxR 423 L	12.50
Wisconsin 644	12.30
Hybrid 29-3 Harris Seed	12.14
Wisconsin 615	12.00
Hybrid 459 Wooster, Ohio	12.00
Mich. Hybrid 561	11.83
Wisconsin 696	11.83
Wisconsin 620	11.50
Hybrid 200 De Kalb	11.33
Illinois Hybrid 586 Funk	11.33
Wisconsin 625	11.00
Northrup King KxR1 L4	10.66
KxR 424 F.B. Northrup King	10.30
Woods Southern Sweepstake	10.14
Hybrid 420, Wooster, Ohio	10.00
Hybrid 421. De Kalb	9.83
Hybrid Illinois 751 DeKalb	7.83



Note:—"Sd." behind a variety name indicates that this is a standard variety. All hybrids are without this mark.

CHART 2.—AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, RIDGETOWN. 1938

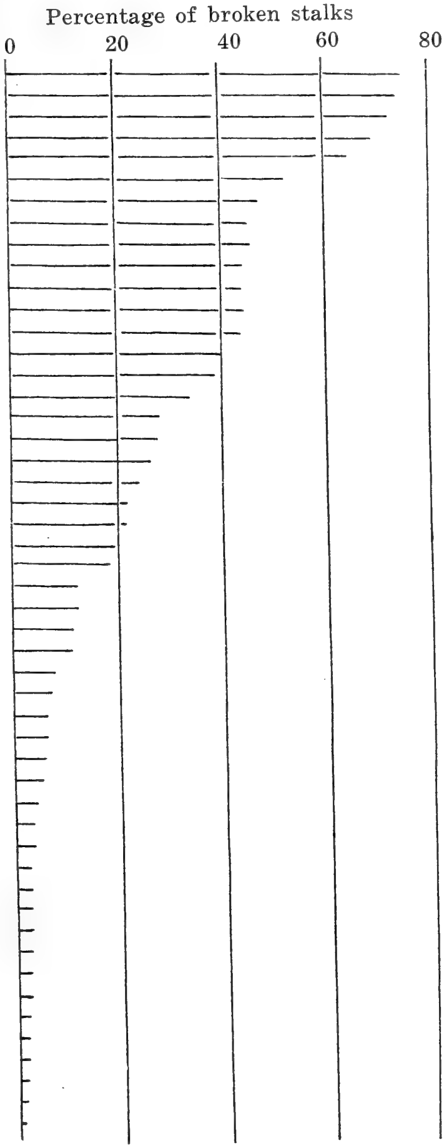
	No. Borers
Northrup King Kx206 D	30.0
Northrup King KxR 425 M	27.0
Wisconsin 645	25.0
Northrup King KxM 700- A2	24.5
Hybrid 421 De Kalb	23.5
Wisconsin 696	22.5
Hybrid Illinois 751 De Kalb	22.5
Hybrid K 23 Wooster, Ohio	22.0
Bailey Sd.	21.5
29-3 XX Cornell Univ.	19.5
Wisconsin No. 7 Sd.	19.5
Longfellow Sd.	19.0
Carter's Crossed Corn	18.5
Hybrid 493 Ke Kalb	18.0
Wisconsin 525	17.5
Saltzer's North Dakota Sd.	17.5
Hybrid K 35 Wooster, Ohio	16.5
Excelsior, Vaughan Seed	16.5
Funk's Hybrid G-15	16.0
Wisconsin 620	15.5
Wisconsin 625	15.5
Canada Golden Glow Cohoe Sd.	15.5
Hybrid 436 Wooster, Ohio	15.0
Michigan Hybrid 561	15.0
Hybrid 202 De Kalb	15.0
Golden Glow Stuart Sd.	14.5
Northrup King KxE 612-E2	14.0
Northrup King KxR 425 M	14.0
Hybrid 459 Wooster, Ohio	14.0
West Branch Sweepstakes Sd.	14.0
Hybrid 420 Wooster, Ohio	13.5
Hybrid 29-3 Harris Seed	13.5
Northrup King KxR 421T	13.0
Illinois Hybrid 586 Funk	13.0
Wisconsin 615	12.5
Northrup King KxR 424 F.B.	12.0
Northrup King KxR1 L4	12.0
Minhybrid 301	12.0
Hybrid 200 De Kalb	11.5
Compton's Early Sd.	11.0
Wisconsin 570	10.5
Funk's Hybrids G-7	10.0
White Cap Yellow Dent Sd.	9.5
Golden Glow A Smith Sd.	9.0
Wisconsin 606	8.5
Wisconsin 655	8.0
Wisconsin 531	7.5
Wisconsin 680	7.0
Northrup King KxR 423 L	6.5
Wisconsin 644	5.0



Note:—"Sd." behind a variety name indicates that this is a standard variety. All hybrids are without this mark.

CHART 3.—AVERAGE PERCENTAGE OF BROKEN DOWN STALKS IN STANDARD AND HYBRID CORN, GUELPH, 1938

Bailey, Sd.	75.8
Norhtrup King KxM 700A2	75.0
Wisconsin No. 7, Sd.	71.5
White Cap Yellow Dent, Sd.	68.3
Golden Glow, Stuart, Sd.	53.3
Longfellow, Maynard, Sd.	47.0
Compton's Early, Sd.	46.3
Northrup King Kx 206D	46.2
Golden Glow, Smith, Sd.	45.5
Salzer's North Dakota Sd.	45.0
West Branch Sweepstakes Sd.	43.1
Excelsior, Vaughan, Sd.	42.0
Michigan Hybrid 561	40.0
Hybrid 29-3, Harris Seed	39.3
Wood's Southern Sweepst. Sd.	32.5
Minhybrid 401	28.8
Northrup King KxE612-E2	28.8
29-3 XX Cornell Univ.	27.3
Hybrid 200 De Kalb	23.7
Wisconsin 570	21.6
Minhybrid 402	20.8
Wisconsin 645	19.5
Carter's Crossed Corn Sd.	19.3
Wisconsin 525	16.9
Wisconsin 615	16.6
Northrup King KxR 423 L	16.1
Hybrid 459 Wooster, Ohio	16.0
Wisconsin 606	14.4
Hybrid 420 Wooster, Ohio	12.5
Hybrid 421 De Kalb	12.0
Wisconsin 644	12.0
Wisconsin 696	11.8
Funk's Hybrid G-7	10.3
Canada Golden Glow Sd.	10.0
Wisconsin 680	9.8
Wisconsin 620	8.4
Hybrid 493 De Kalb	8.3
Funk's Hybrid G-15	8.3
Hybrid K 23 Wooster, Ohio	8.1
Northrup King KxR1 L4	7.5
Hybrid K 35 Wooster, Ohio	7.1
Northrup King KxR 424 FB.	6.6
Wisconsin 531	5.0
Illinois Hybrid 586 Funk	5.0
Northrup King KxR 421 T	4.5
Minhybrid 301	4.5
Wisconsin 655	4.5
Hybrid 436 Woster, Ohio	3.5
Wisconsin 625	3.0
Hybrid 202 De Kalb	1.7
Hybrid Illinois 751 De Kalb	0.0



Note:—"Sd." behind a variety name indicates that this is a standard variety. All hybrids are without this mark.

Charts 1 and 2 show that at least some of the Wisconsin hybrids, as well as some commercially developed hybrids, indicate considerable promise for borer resistance in contrast with the standard varieties included in these tests. A comparison of the borer populations for 1937 and 1938 indicate that the borer resistance, which was shown by hybrids last year, has been, in a number of cases, repeated this year, which should mean that some of the hybrids have distinct promise along this line. Slightly larger percentage reductions in borer populations are shown this year at both Guelph and Ridgetown by hybrids, and in a case or two represent more than 75 per cent reduction, despite the fact that the general borer infestation is smaller in the territory immediately surrounding the experimental plots.

In Chart 3, the counts of broken or bent stalks are expressed as percentages of the full number of stalks in the row from which stalks were taken for dissection. This chart is constructed from data collected in the Guelph plots only, but these results are very similar to those recorded from visual estimates from Ridgetown. Stalks included in these counts were either broken down by borer feeding or had been bent over to an angle of less than 45 deg. with the soil surface, as a result of heavy wind which occurred in August. This factor of weak stalks assumes importance when it is considered that nearly all the hybrids have demonstrated a stiffness or strength of stalk in contrast to the standard varieties. In almost every case, as can be seen from Chart 3, the standard varieties were badly broken down. Of the 12 standard varieties shown, two only have less than 30 per cent of stalk breakage, while 34 of the 39 hybrids have less than 30 per cent of their stalks broken or bent. There seems to be no doubt that these figures are a direct result of the greater strength of the hybrid stalks. The bending of stalks, which is prevalent among the standard varieties, seems, in some cases, to be explained by their poorer root systems, the aerial roots of which are far less numerous and decidedly less sturdy than those of the hybrids.

In most cases, the hybrids, which are showing promise from the standpoint of borer resistance and of strength of stalk, are equivalent to the common standard varieties on the basis of yield and date of maturity. Data in connection with maturing dates and yields are dealt with as agronomic aspects of the problem and are to be found in the Field Husbandry reports at the Ontario Agricultural College.

Further work will be carried on with these hybrids and standard varieties in order to determine if the hybrids will continue to show the promise which they have already indicated in the experiments up to the present.

In last year's report, by reason of the fact that a marked increase in borer infestation of corn stalks occurred in Essex and Kent counties, these two counties were featured. As a result, only brief mention was made of the remainder of the territory under the Act. The following table which represents the results of the annual infestation survey in counties under the Act has been included, so that infestation data are available for these counties since 1926. In cases where figures in bold face type appear the percentage figures were obtained by Dominion Department scouts. In all other cases, the figures are from Provincial records.

It will be noted that in Essex County this year there is quite a substantial reduction in the percentage of stalks infested, in comparison with that for 1937. The explanation of this reduction seems to be found in the good

clean-up of corn refuse which was obtained this spring. For some time in the spring of this year it appeared that there would be a big increase in borer population in this county, but a concentrated effort on the part of a large staff of assistant inspectors was rewarded by perhaps the best clean-up that has been obtained in Essex since the inception of enforced clean-up measures. In Kent County there was also a decrease in infestation, and while the actual figure shown does not indicate as big a reduction in Kent as in Essex, such has been actually the case except for the area including Chatham, Wallaceburg, and Dresden. In this area there are many heavily infested fields which must of necessity have an influence on a figure which represents an average of conditions found over a whole county. In Elgin, Lambton, Halton and Wellington Counties, there is an increase in the percentage of stalks infested. In the remainder of the counties under the Act, where counts were made in 1938, the stalk infestation has remained about the same as in 1937, or has decreased slightly. The explanation of the decrease in Essex County particularly, and also in Kent County, seems to have been mainly a result of clean-up, although the amount of moisture which occurred during the period of moth flight, oviposition and larval establishment, was slightly less than in Elgin and Lambton Counties.

Reference

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CHART 4.—PERCENTAGE OF STALKS INFESTED BY CORN BORER BY COUNTIES, 1926 TO 1938.

County	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
Brant	**10.3**	15.6	14.9	10.3	......	7.3	15.0	14.5	......	3.1	3.5	18.6	......
Durham	......	**6.3**	......	20.6	12.4	10.7	......	......	9.4	17.1	15.0	18.0	27.0
Elgin	47.7	37.1	24.0	20.9	9.0	17.1	22.5	16.6	6.6	17.7	16.0	25.0	50.0
Essex	**83.0**	64.7	41.7	35.9	16.7	27.6	27.7	29.5	8.5	19.7	31.5	47.0	34.0
Haldimand	**3.8**	21.9	12.2	7.8	......	......	......	......	5.6	4.1	5.5	15.0	......
Halton	......	......	......	8.7	11.8	12.7	11.6	16.6	11.0	7.8	15.0	7.0	20.0
Hastings	......	......	......	9.9	26.8	13.3	......	......	......	......	25.0	13.0	......
Huron	**11.4**	17.2	12.0	16.1	......	......	......	28.0	......	13.7	......	15.7	......
Kent	69.5	48.8	35.0	21.4	22.2	26.9	28.5	35.0	6.2	23.5	20.0	44.0	42.0
Lambton	34.0	56.9	21.4	14.2	7.4	......	34.5	23.3	7.5	20.9	20.1	31.2	41.0
Lennox	**0.5**	**1.8**	**11.9**	**21.5**	33.0	26.9	18.7	18.0	......	......	46.0	18.0	......
Lincoln	**5.3**	42.7	29.7	10.8	8.9	11.3	12.9	20.0	5.3	4.0	11.7	6.3	......
Middlesex	**28.5**	36.2	18.3	9.9	9.0	14.5	21.6	20.0	4.6	5.9	13.5	22.2	34.0
Norfolk	16.1	10.1	19.7	6.1	5.1	5.2	10.7	9.4	3.3	9.3	3.7	29.8	26.0
Northumberland	......	......	......	18.2	16.4	8.2	......	......	5.0	......	15.0	13.0	......
Ontario	......	......	......	8.6	4.2	5.2	......	......	15.2	16.5	22.5	18.5	21.0
Oxford	31.2	14.2	14.7	17.5	......	13.2	15.7	17.0	6.0	16.8	18.5	33.6	29.0
Peel	......	......	10.4	18.5	17.3	21.5	29.3	39.0	11.0	11.9	11.5	11.2	......
Pelee Island	......	......	15.0	23.6	4.8	6.0	7.1	12.0	3.8	9.0	12.5	22.0	13.0
Perth	......	7.5	9.3	15.6	......	......	......	6.4	......	11.8	......	20.0	......
Prince Edward	......	......	17.6	21.3	27.8	16.9	......	......	......	44.0	26.7	22.0	......
Waterloo	......	......	7.8	4.6	......	......	13.2	10.8	......	7.3	......	12.2	......
Welland	**23.7**	41.0	25.5	5.0	13.6	10.2	......	7.5	1.5	4.1	4.0	15.5	12.2
Wellington	......	......	......	8.0	5.2	......	9.4	......	......	6.6	10.4	2.7	......
Wentworth	......	22.0	24.6	9.0	13.3	8.2	16.6	18.5	7.7	5.8	7.0	12.0	17.1
York	......	......	......	......	......	4.9	21.7	......	......	16.0	7.5	28.2	......

SOME FIELD OBSERVATIONS ON THE BIOLOGY OF *CHELONUS ANNULIPES* WESM., AN INTRODUCED BRACONID PARASITE OF THE EUROPEAN CORN BORER

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During 1936 a field investigation was carried out in Prince Ewdard County for the purpose of studying the seasonal development of *Chelonus annulipes* Wesm., a recently introduced parasite of the European corn borer. Following liberations in 1935, the parasite showed promise of establishment at several points in the county, particularly at Mount Pleasant, where parasitism averaged from 2.5 to 11 per cent. Sampling in the experimental field during April, 1936, showed a fairly even distribution of parasitized corn borers throughout the stubble and debris, although at this time the actual parasitism was found to be greater among the debris borers than among those found in the stubble (4.8 per cent : 2.9 per cent).

A supplementary field study of the parasite was made at Carrying Place, 14 miles north-west of Mount Pleasant, in order to obtain comparable data from an area in which the parasite colony had been maintained since 1931 without supporting liberations. In this field eight and six per cent parasitism were recorded respectively from debris and stubble.

Description of the Fields.—The soils in the Mount Pleasant area vary between clay loam and the characteristic stony clay of Prince Edward County. Considerable field corn is grown on the heavier land, and on the higher stony clay land orchards are common. In the two-acre experimental field located on the farm of Howard Leavens, both soil types were represented. The lower half of the field was situated in a small depression of the late draining clay loam, the remainder being characterized by stony clay land common to the adjacent cherry and apple orchards. Overwintering *Chelonus* were confined to the five-inch stubble and debris remaining from the previous crop of sweet corn. Following the usual stubble clean-up in May, 1936, a quarter acre strip of the same field was sown with Golden Bantam corn to provide an oviposition plot in which to study the summer parasitism.

At Carrying Place the *Chelonus* colony was found to be localized in fields occupying a northern slope over-looking the Bay of Quinte. The soil along the face of this slope may be described as a stony clay loam which drains readily in the spring and is, therefore, well suited for early corn growth. The lower levels of the slope are separated from the beach by a shoreline thicket, formed by a mixed succession of young Manitoba maple, peach-leaved willow and paper birch, bordered on the leeward side by chokecherry and sumach (*Rhus typhina* L.). These trees and shrubs together with their undergrowth, form an effective screen to the fields in question. The two-acre experimental field was located on the farm of Wm. Allison. An early crop of sweet corn has been harvested from the same field for several years.

Spring Emergence, 1936.—Under conditions in Southern Ontario, *Chelonus annulipes* overwinters as a first stage larva within its fourth instar host, resuming growth the following spring. The spring development of the parasite in 1936 was studied from frequent collections of par-

asitized host larvae made from the beginning of May until the emergence of the parasite in June. The first advance from the hibernating phase, as indicated by changes in the size and form of the body segments, was noted on May 5. The progress in development is summarized in Table 1.

TABLE 1.—SPRING DEVELOPMENT OF *CHELONUS ANNULIPES* AT MOUNT PLEASANT, 1936

Stage	Date 1936	Average head width of larva	Average diameter at anal vesicle	Length
I (hibernating)	May 2	.08 mm.	.4 mm.	1.8 mm.
II	May 5	.36	.5	2.6
II (late)	May 13	.45	.6	3.3
III (external)	June 6	1.0	1.5	9.4

The development of *Chelonus* was somewhat retarded at Carrying Place during the first two weeks in May. Development, however, was later more rapid, since pupation was underway by June 6 at both localities. Corn borer eggs were first found at Carrying Place on June 26, when counts on 200 hills showed that 1.5 per cent were infested. On June 29 both adults and empty cocoons of *Chelonus* were observed in the field, which shows that in 1936 the parasite emergence was synchronized with the beginning of the corn borer moth flight.

Burial Experiments—The question of the survival of parasitized borers hibernating in stubble and debris and subsequently buried in clean-up operations, suggested some simple burial experiments with such larvae. In the first experiment, begun on May 5, corn stalks containlng 500 borers were buried under four inches of loam in a six by five feet burial cage, fitted with traps to catch issuing larvae. The resulting counts showed that the normal borers came to the surface somewhat more rapidly during the first four days. During the next 12 days, however, the relative emergence between parasitized and unparasitized borers was similar. Complete emergence was extended over a period of two weeks.

On May 28 similar tests were made, using only parasitized borers in order to compare their emergence from sandy loam with that from the stony clay of the Carrying Place field. In this experiment lots of 25 larvae were buried in each type of soil at depths of two and four inches. The results showed that the majority of the larvae buried in sandy loam emerged after two days, while total emergence was completed in five days. With the larvae buried in the stony clay, emergence was slower and was continued for 12 days, the highest emergence being recorded on the fifth day following burial. The depth of burial apparently delayed the movement of the larvae, but had no effect on the total number of larvae trapped. Assuming that the parasitized larvae in the experimental fields behaved in a similar manner, the above experiments would indicate that the delayed parasite development at Carrying Place in May was partly due to the slower emergence of the parasitized borers through the soil at that time.

Summer Parasitism.—Data on the seasonal history of *Chelonus* from the egg to hibernating larva, were secured from field collected host eggs and larvae. Fresh egg masses were dated and after an exposure to parasitism of from one to four days, were removed from the corn leaves and fixed in warm Bouin's fluid for future study. From the examination of 106 egg

masses, it was evident that both eggs and first instar larvae were present in the field by July 3, if not earlier. The parasite larvae were farther advanced at Carrying Place, due perhaps to the fact that corn borer eggs were available for the parasite earlier in that locality. Parasite eggs were not easy to demonstrate in this field material so that little can be said regarding the age of the host eggs favoured by the female *Chelonus*. However, judging by the growth and position of the larvae in the host eggs that were examined, it would appear that there was a preference for eggs two days old.

Table 2 presents the results from the dissection of parastized corn borer larvae collected at ten-day intervals between July 22 and September 8.

TABLE 2.—COMPARATIVE GROWTH OF FIRST INSTAR LARVAE OF *CHELONUS ANNULIPES*

Date		Average length	Diameter at anal vesicle	Host instar
Mount Pleasant				
July	22	.7 mm.	.13 mm.	II
Aug.	1	.7	.16	II-III
Ang.	12	1.35	.23	IV
Aug	22	1.7	.35	IV
Aug.	30	1.8	.35	IV
Sept.	8	1.9	.35	IV
Carrying Place				
July	24	.9	.2	III
Aug.	4	1.3	.25	III-IV
Aug.	13	1.5	.25	IV
Aug.	22	1.4	.25	IV

From this table it is evident that the advanced parasite growth already noted at Carrying Place continued throughout July, and was apparently correlated with advanced corn borer development.

Another point emphasizing the difference in growth behaviour between larvae from the two fields appears from the fact that the Carrying Place larvae completed their summer growth by the middle of August. On the other hand, growth at the inland field was continued during September until the parasite averaged 1.8 mm. in length. These larvae were similar to those collected at Mount Pleasant in the previous spring, which suggests that *Chelonus* overwintered at that point in a more mature phase.

The information obtained indicates excellent synchronization in seasonal history of host and parasite. The difference in fall development of the parasite in the two areas suggests the influence of some unknown factor which may be partially responsible for the very localized establishment and distribution of *Chelonus annulipes* both in America and Europe.

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SOME OBSERVATIONS ON THE EFFECT OF TEMPERATURE ON THE SEX RATIO OF A HYMENOPTEROUS PARASITE *CHELONUS ANNULIPES* WESM.

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One of the major difficulties encountered in rearing hymenopterous parasites in the laboratory is that of securing females in numbers comparable to those found in nature. Considerable time has been spent by the writer in an attempt to determine what factors govern the numbers of females secured in the laboratory rearing of *Chelonus annulipes* Wesm. From the beginning the desirability of investigating the effect of temperature on the sex ratio was appreciated but two factors prevented this from being done.

Until the spring of 1937 the practice had been to rear *C. annulipes* on the European corn borer, *Pyrausta nubilalis* Hubn. The latter had been reared in the laboratory on such succulent foods as string beans, curled dock, (*Rumex crispus*), and mangels. Long experience has shown that to get satisfactory numbers of the host through they must be reared at temperatures of from 80 deg. to 85 deg. F. Lower temperatures prolong the time of rearing, and thus increase the hazards, making the mortality much higher. In the second place the strain of the corn borer with which we have been working is known as the one-generation strain, having but one generation per year. It is very easily thrown into diapause, and, to prevent this, great care must be taken to maintain the growing larvae at constantly high temperatures. Even with such precautions, a relatively small proportion of unparasitized laboratory reared larvae will form pupae. This tendency to diapause is important in its effect on *C. annulipes* which appears to have no definite tendency of its own, but seems to respond to the reaction of the host in this respect. That is, if the host has a tendency to go into diapause when the temperature is lowered, the parasite will do likewise.. The matter is so critical in the case of the corn borer and *C. annulipes,* that in the writer's work there has always been a small percentage of *C. annulipes* go into diapause in spite of consistently high rearing temperatures. It will be evident from the above that experiments with varying temperatures at the time of rearing of the parasitized host larvae were impractical as long as the corn borer was used as the host.

Early in 1937 following the advice of W.A. Baker (1) breeding on *Ephestia kuehniella* Zell. as host was started. C. *annulipes* attacks the eggs of this insect much less readily than those of the corn borer and, due to its smaller size, the parasites themselves are smaller. Otherwise, however, *E. kuehniella* has proved to be a very satisfactory host for large scale laboratory breeding. Also, since it showed no diapause tendency, it was possible to study the effect on the sex ratio of *C. annulipes* of the temperature at which the parasitized larvae were reared. At the time of writing this study is incomplete, but it is felt that sufficient data are available to be of some significance.

The first experiment was designed to determine the effect of temperature on the sex ratio of the present generation. *E. kuehniella* eggs, stuck to cards, were presented for parasitism after which each card was counted, and placed in a jar with one gram of whole wheat meal for each cut into four approximately equal sections. The eggs on each section were counted, and placed in a jar with one gram of whole wheat meal for each

egg. The jars were then placed in four incubators, operating at the following temperatures :incubator A, 90 deg. F; incubator B, 80 deg. F; incubator C, 70 deg. F; incubator D, 60 deg. F. A total of 25 lots was thus treated. In the material incubated at 60 deg. F, the temperature apparently was below the threshold of development for *C. annulipes,* as none of the parasites advanced beyond the first stage. The data for the other three temperatures are given in Table 1. Although the percentages of parasitism secured were quite low, and the numbers in the 70 deg. F. class lower than in the others, the number of females was greater than in those incubated at 80 deg. F. or 90 deg. F., and the percentage of females was considerably greater. If the data are sufficient to be significant, they indicate that there was some selective elimination of females at the higher temperatures.

TABLE 1.—EFFECT OF TEMPERATURE AT WHICH HOST LARVAE ARE REARED ON SEX RATIO.

A 90 Deg. F.				B 80 Deg. F.				C 70 Deg. F.			
Eggs	Male	Female	% Female	Eggs	Male	Female	% Female	Eggs	Male	Female	% Female
57		1	100	39	6	1	14	30			0
60	4		0	45	1		0	55			0
79	16		0	83	9		0	72	14		0
62	14	1	6	50	11		0	68	9		0
70	12	1	7	72	14	7	33	74	7	5	41
112	4		0	104	3		0	84	4		0
81	8	2	20	89	3	5	62	90	7	6	46
81	6		0	103	13	2	13	80	3	1	25
111	28	12	30	103	23	4	14	97	18	9	35
103	26		0	117	38	2	5	123	19		0
160	26	4	13	162	28	2	6	106	6	1	14
140	10	1	9	143	19	0	0	152	3	1	25
162	1		0	148				176			
103	4		0	112	5			115	3		
107	13		0	93	16	3	15	114	6	1	14
130	7	0	0	78	5	1	16	142	8	5	38
116	1		0	110	2	1	33	123	3	1	25
98	6	1	14	108	2		0	118			
99	3		0	96	8	2	20	100	2	1	33
198	3	2	40	152	11	1	8	170	12	2	14
143	4		0	154	8	2	20	153	6	2	25
110	1		0	132	7		0	129			
163	2		0	126	1	2	66	160	4	1	20
105	4		0	114	7		0	104	3		0
114	5		0	124	6		0	123	2	1	33
	208	25	10.7		246	35	12.4		139	37	21.0

The second experiment was designed to test the effect on the sex ratio when the parents were reared at high or low temperatures. For this purpose males and females reared at 90 deg. F. were mated, and males and females reared at 70 deg. F. were mated. Eggs were presented for parasitism to each group at room temperature (72 deg. F.), and the parasitized material was all reared at 80 deg. F. The results are presented in Table 2.

TABLE 2.—EFFECT OF TEMPERATURE AT WHICH PARENTS ARE REARED ON SEX RATIO

Parents reared at 90 deg. F.			Parents reared at 70 deg. F.		
Progeny reared at 80 deg. F.			Progeny reared at 80 deg. F.		
Male	Female	% Female	Male	Female	% Female
29	10	25	3	6	66
32	9	20			
50	11	18			
36	20	35			
36	11	23			
4	5	55			
29	0	0	5	34	87
23	0	0			
29	0	0	11	15	57
29	0	0			
21	0	0	9	12	57
58		0	7	1	12
			3	7	70
376	66	14.9	38	75	66.3

The data indicate that individuals reared during their larval life at high temperatures are incapable of producing as high a percentage of females as those reared at low temperatures. Since this species is arrhenotokous, producing males without fertilization and, since males were produced quite freely from the material reared at 90 deg. F., it would appear that the deleterious effect operated against the males. Young and Plough (1926) (2) found that in *Drosophila* high temperatures have a differential effect, such that males may be rendered completely sterile at a point at which females are still completely fertile, and that high temperatures seem to reduce the motility of the sperms. A partial sterility of the males may have occurred in the males reared at 90 deg. F. or, as suggested by Young and Plough, the results may have been produced by a lack of motility in the sperms.

References

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WHITE GRUB PROSPECTS IN ONTARIO FOR 1939

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In previous reports of white grub surveys in Ontario and Quebec attention was focussed on the point that the duration of the life-cycle was always a three-year period and that this occurred with remarkable constancy over a relatively long period of years. However, it was also pointed out that the life-history stages were not uniform over the two Provinces and that the principal phases of development in progress in one area might be either one year behind or one year in advance of those in another area a comparatively short distance away.

In Quebec, three distinct and independent life-history rhythms were isolated, each occupying a three-year period. The life-history cycle found to occur in the upper Ottawa valley in Quebec from Papineau county west-

ward was also found over eastern, central and western Ontario regardless of the change in number of species present in the central and western sections. In Ontario, two distinct life-history rhythms were found, the one referred to above and one in the Oshawa and Niagara districts similar in rhythm to that found over southern and a large part of central Quebec. This means that the major flight and other stages occur during the same year in both areas. It was also evident that the second year grub stage caused practically all of the direct injury to crops and that during the intervening years injury was of short duration or of minor importance.

Therefore, knowing the area of distribution of a given life cycle and the particular rhythm which it followed, it is a comparatively simple matter to forecast the year of major June beetle flight, the year of the destructive second-year grub stage and the time of occurrence of the comparatively inactive third-year grub stage which is the year in which the grubs change into June beetles but remain in the soil until the following spring. These points were of primary importance in developing a direct control programme.

Surveys conducted over the chief agricultural areas of Ontario during 1935 for the first time have been reported*. A major June beetle flight was outlined over most of the province of Ontario and second year grub outbreaks were studied in both the Niagara and Oshawa districts. During 1936, third year grub developments were observed in the latter district and second year white grub surveys were conducted over five significant June beetle flight areas found the previous year. During 1937, major flights were studied in the Niagara and Oshawa areas and third year development was checked at various points elsewhere. In 1938, as was indicated from the three-year life cycle, second year white grubs were the typical stages over the Niagara and Oshawa districts. The same stage was found, also, over southern and central Quebec.

In the Niagara Peninsula serious white grub injury was experienced to beans, corn, potatoes, strawberries, pasture, meadow, lawns and also to fall wheat. The greater part of the injury occurred between Dunnville and Welland and the species *P. rugosa* Melch. was largely responsible. In the Oshawa district much greater injury occurred and in addition to the foregoing crops garden vegetables and flowering plants were injured in many cases. In Uxbridge Township of Ontario County thousands of acres of pasture were largely rendered useless for live stock and at the same time many of these pastures, located on the higher parts of the rounded hills or drumlins, will be subject to serious erosion during the autumn and spring before natural or planted vegetation becomes effective in preventing it. No important white grub injury will occur here or in the Niagara Peninsula until 1941.

In a large part of Ontario, however, where major June beetle flights occurred during 1938 it is desirable and important that precautions be taken to avoid crop injury prior to the actual attack of the second year grubs during 1939. There are five distinct infestations known at present in which important June beetle flights occurred during 1938 and which are separated by areas in which the flight was too light to be of economic significance. One infested area occurs in eastern Ontario, involving the Counties of Leeds, Grenville, Dundas, Stormont, Glengarry, Prescott, Russell, Lanark and Carleton. June beetle flights over this section were varied from locality to locality and were distinctly below the great flights of

*Hammond G. H., 1936. White grub surveys in Ontario during 1935. 66th Ann. Rep. Ent. Soc. Ont. pps. 42-45.

1929 and 1932. A moderate amount of injury to hoed crops is looked for, with little injury occurring to grain crops.

Another area of infestation, located largely over the central parts of Hastings and Peterborough Counties, is the most important in Ontario at present. Very heavy June beetle flights occurred during the early part of 1938, followed by serious defoliation to many forest and woodlot trees. The infestation as a whole has not receded to any extent from its former intensity. Soil sampling in this area in 1938 indicated first year white grubs to the number of 400 per square yard and an average of over 100 per square yard in some old meadows, sufficient to kill out all vegetation with the possible exception of sweet clover and alfalfa. Needless to say losses expected during 1939 will reach a high figure, with much permanent pasture in the infestation zone being largely killed out. It will be unsafe to plant hoed crops in either pasture or meadow sod without control precautions and grain crops will also have to be planted with care to avoid serious damage. Unfortunately a large part of the autumn ploughing was performed in October or November 1938, after the grubs had descended to hibernation depths for the winter and, therefore, normal field ploughing must be regarded as having been of little value in respect to control. However, with careful application of the shallow ploughing, multiple-discing control method in early May of 1939 the grubs can be successfully reduced to a point where no injury to susceptible crops will occur. The two species *P. anxia* Lec. and *P. fusca* Froe. were about equally common.

A third area of infestation occurs in the vicinity of Lake Simcoe, generally distributed around the lake with the greatest abundance of insects in the south and southwestern sections. June beetle flights were particularly heavy between Queensville, Leaskdale and the lake margin, reaching maximum concentrations over the lighter soil of the lower levels, shown by serious defoliation of many trees over a wide area. The whole southern part of Simcoe County was largely involved, together with some of the adjacent northerly part of York and the part of Ontario County between Uxbridge and the lake. Injury to pastures, meadows and hoed crops is liable to be important in this area during 1939, although the infestation will be irregular and spotty as compared with the Hastings- Peterborough area.

An infested area is also present in Bruce County; this also includes a part of Grey and Huron Counties. Bruce County had a moderate flight of June beetles in 1938 which extended for some distance into the Bruce peninsula. June beetle feeding on the leaves of various species of trees was moderate or light, and the principal species in the district was *P. rugosa* Melsh. Some important, although spotty injury is looked for during 1939, especially in the vicinity of Port Elgin and Southampton; therefore hoed crops should be planted with care, especially where old pasture or meadow is being converted to hoed crops.

A southwestern Ontario infestation, the largest and one of the most important in Ontario is also recognized. It is separated from adjacent infestations by areas of heavy loam or clay soil. The June beetle flight occurring over this section in 1938 was much larger than that experienced during 1935 and, therefore, important injury can be expected during 1939. Beetles were most abundant in the Counties of Huron, Perth, Waterloo, Brant, Wentworth, Oxford, Middlesex, and Kent ,but were also found to occur in important numbers in parts of Wellington, Halton, Norfolk, Elgin, Essex, and Lambton Counties. Defoliation of many species of trees was observed almost continuously between Watford and Guelph, due principal-

ly to feeding by the species *P. futilis* Lec. In this zone of June beetle abundance there is an association between soil type and degree of white grub infestation which is more marked than in any other of the infestation zones. This will have an influence on the amount of injury to be expected on individual farms, crops on sandy soils being more likely to be injured than those on loam or clay. Despite the fact that a large acreage of alfalfa is grown in this area and excellent farming methods are practised, considerable white grub injury may be looked for during 1939 on account of the comparatively large number of first year white grubs present in the autumn of 1938. Most of the danger will arise from the practice of planting old meadows or pastures to hoed crops like corn and potatoes without adequate application of cultural control practices. Some measure of control has already been secured with early autumn ploughing and for such cases subsequent cultural control need not be quite so thorough. In general, however, the possibility of severe losses from white grubs in 1939 should be kept in mind in cropping light land throughout this zone.

In conclusion—second year white grubs caused their maximum injury to crops during 1938 in the Niagara peninsula and in the southerly sections of the counties of York, Ontario and Durham, and will cause little direct injury to crops during 1939. Throughout the greater part of Ontario second year grubs will be prevalent as indicated in the foregoing areas of infestation.

THE MOST VULNERABLE STAGE IN THE LIFE CYCLE OF JUNE BEETLES

By Georges Maheux and Georges Gauthier

Plant Protection Service, Quebec

Following the good work done on the distribution and biology of June beetles in Quebec by our friend Mr. George Hammond, Ottawa, the authors have, since 1935, tried to solve the problem of white grub control. Our object was to find a simple, economical and efficient method which any farmer could easily understand and apply. It was felt that the solution should be limited to the timely application of well known cultural methods and the use of ordinary farm implements. The necessity for arriving at a satisfactory solution with the least possible delay had year after year become more and more urgent. Meanwhile white grub damage rapidly increased in the Eastern Townships and also in the section north of Montreal; and requests for help became more and more numerous.

Right at the outset attention was concentrated on finding the most vulnerable point of attack on the insect. Where was the line of least resistance along its three years of activity and transformations? Would the adults be more vulnerable than the larvae? Or, would the pupae show greater susceptibility than the 1st, 2nd or 3rd year grubs? This called for work on the different stages in order to discover at what period of its life the beetle could be most successfully controlled.

In the spring of 1936, June beetles were scheduled to come out in swarming numbers in the Montreal district and trapping of the adults was, therefore, given careful attention. Trapping was also conducted the following year in the Eastern Townships but the results were far from satisfactory. In fact, only a small proportion of females (about 12%), were attracted to the light traps. There did not appear to be any reason to believe that the capture of 88 percent of the males would have an important bearing on the propagation of the species when the sex ratio was nearly

one to one and when this slaughter had no perceptible effect on egg fertility. However, control measures directed against white grubs of different ages gave much more satisfactory results. Timely ploughing and harrowing, the choice of resistant crops, and more thorough preparation of the soil helped the farmers to a great extent, as about 65 per cent of the larvae could be killed by these methods. At the same time these practices called for much precaution and moreover were rather complicated for the ordinary farmer who insisted on something relatively simple. There remained the possibility that the pupal stage would offer better chances for successful attack.

Preliminary experiments made in 1936 indicated that ploughing and harrowing during the period of the pupal stage brought about a much higher percentage of killing. These results were presented at the meeting of the Quebec Society for the Protection of Plants in the spring of 1937, and a resume was published in Volume III of the "Annales de l'Acfas" (page 105). In this resume we pointed out that "the moment of least resistance takes place at the end of the 3rd year of larval life, that is during the three or four weeks of the pupal stage. When disturbed by the plough or harrow or any other cause, during this period of latent life when the tissues are extremely delicate, the pupae die in astonishing numbers; if, perchance, they succeed in transforming into adults, they are but imperfect imagoes whose wings remain embryonic." These observations indicated the possibility of finding, within a couple of years, a definite solution to the white grub problem in Quebec. The period of vulnerability being discovered there remained the necessity of finding some method of attack or to determine the conditions required to reach the desired result.

As you are aware, before transforming into pupae white grubs of the 3rd year bury themselves five or six inches in the soil and there build an oval cell. These cells are apparently made of particles of soil glued together by the saliva of the grub and located in the upper layer of soil (at least in light sandy types).

This year at Ste. Cecile de Milton, Shefford County, we observed on the 15th of June that many white grubs had already built or were building their cells. On the 25th of the same month, 25 per cent. of these grubs were already transformed into pupae. On the 25th of July, 50 per cent had reached the adult stage. The necessity of a cell for the protection of the pupa is easily understood. If we open a cell, we see immediately how fragile is this stage of the insect. The outer surface is extremely delicate. The cell serves as a protection against pressure of the soil, loss or excess of humidity or heat, and probably also against certain enemies. If you take one of these pupae between your fingers, you note that the slightest pressure breaks the tegument and a whitish liquid comes out as if this very thin envelope was entirely filled with a milk-like substance. Within the cell, the pupa enjoys the quietness and security absolutely necessary to complete its development. Without it, the pupa is very soon exposed to various factors of destruction. The cell measures about 1½ inch in length and about ¾ of an inch in diameter.

The cages used in our experiments measured 12 in. by 6 in. in height and the bottom was covered with wire screen to allow for free circulation of water. In each of these cages about an inch of soil was placed together with 50 pupae previously extracted from the soil with the greatest care. About 6 inches of loose soil was put in the box on top of the pupae in order to place the specimens as nearly as possible under the same conditions of environment they normally enjoy except that they were deprived of their cells.

The following table will show the number of pupae used in the different boxes and the observations made 3 weeks later.

TABLE 1.—CONTROL OF WHITE GRUBS IN THE PUPAL STAGE, 1938.

Date of the capture	Number	Time exposed in the sun	Date of the result	% alive
July 2	150		Aug. 24	0.6
July 15	150		Aug. 17	3.3
July 28	150		Aug. 24	0.0
Aug. 3	50	3 hours	Aug. 24	0.0
Aug. 3	50	6 "	Aug. 24	0.0
Aug. 3	50	12 "	Aug. 24	0.0
Aug. 3	50 adults		Aug. 24	50.0
July 2	50 larvae		Aug. 24	0.0

From this table it will be seen that on the 2nd of July 150 pupae were placed in three cages, care being taken that they should not be exposed to sunshine between the time of their extraction from their cells and the moment they were placed in the boxes. The same procedure was followed on the 15th and 28th of July. The examination of these pupae was made on the 17th and 24th of August, when the majority of the grubs in the field had already transformed into adults. Out of a total of 450 pupae contained in nine cages, only six, or 1.33 per cent, were still alive; but none of these six surviving pupae had reached the adult stage. Obviously, they were unable to complete their development.

On the 3rd of August, 150 pupae were taken from the soil. 50 were exposed to sunshine for three hours and then placed in cages. 50 others were exposed to sunshine for six hours; and the last lot was exposed for 12 hours. The boxes were placed in the soil, as in the case of the first experiment, and on the 24th of August, exactly three weeks later, examination showed that the degree of mortality had reached 100 per cent.

On the same date, 50 newly born adults were placed in similar cages and on the 24th of August 50 per cent were still alive.

An identical experiment was made with 50 third year grubs which were in the process of making their cells. They were all dead on the 24th of August. These results indicate that pupae (or larvae on the eve of transformation into pupae) when disturbed or exposed to sunshine are very susceptible to injury. Of course, we do not forget that in these cages the insects were taken out of their normal environment and that this was possibly sufficient to weaken or even kill many of them.

TABLE 2.—CONTROLLING WHITE GRUBS IN THE PUPAL STAGE BY PLOUGHING AND DISCING, 1938

Date of ploughing	Date of 1st discing	Date of 2nd discing	% destroyed indirectly by ploughing	% destroyed directly by horses and ploughs	% destroyed by discing	alive
July 2	July 12	July 28	85	5	10	0.
July 15	July 28	Aug. 3	85	5	10	0.
July 28	Aug. 3	Aug. 13	70	5	15	5.
Aug. 3	Aug. 13	Aug. 24	60	5	25	10.

It therefore remained for us to demonstrate what would be the result if the pupae were left in their normal environment and the soil subjected to ploughing and discing. As shown in the second table, four plots were ploughed at four different dates, namely on the 2nd, 15th, 28th of July

and on the 3rd of August. In each plot, ploughing was followed with two discings at intervals varying from 10 to 15 days. Counts made after each operation and after the last discing revealed even more satisfactory results than had been expected. In the first two plots where the work had been done at the optimum moment, that is before any pupa had transformed into adults, all the pupae were killed in the following manner: five per cent directly crushed by the plough and horses, 85 per cent killed indirectly by the pressure or twisting developed in the strip of soil turned by the plough, and 10 per cent by the two soil discings. At a later date, it was found that a number of newly born adults could survive, five per cent in one case and 10 per cent in the second. At this time, the harrow killed a larger percentage than earlier in the season.

Judging from the results of these experiments it appears obvious that the pupa is the most vulnerable stage in the June beetle's life cycle. The pest can be easily and efficiently controlled if the farmer will decide to keep his land idle for this purpose during the latter part of the summer at the end of the third year of the larval life of the insect. For complete success, ploughing should be done about the 25th of July. However, quite satisfactory results will be secured if control measures are delayed until about the first of August. In this connection it should be noted that the percentage of killing slowly decreases after the majority of the larvae have pupated.

Our advice to farmers may now take the form of a simple and clear motto: "To control white grubs, kill the pupae!"

RECENT DEVELOPMENTS IN CABBAGE WORM CONTROL ON LONG ISLAND

By H. C. HUCKETT

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During the past five years there have been some notable changes on Long Island relative to the use of insecticides for the control of cabbage worms*. The reason for such changes may be briefly explained by the fact that in the fall of 1932 a large proportion of the cauliflower crop offered for sale was found to possess arsenical residues in excess of the legal tolerance. This condition had the effect of disorganizing the orderly procedure of marketing some 500,000 crates of cauliflower.

The control of cabbage worms on Long Island is obtained largely by means of dusts, and until recently arsenical-hydrated lime mixtures have been in general use. It seemed inevitable as a result of dusting that some of the material should tend to collect at the base of the leaves, and there form a durable deposit. In an attempt to alleviate difficulties produce was permitted to be sold provided heads of cauliflower had been trimmed to within two or three leaves of the curd, a precaution that served invariably to eliminate the presence of excessive arsenical residues on the marketed product. Such measures gave temporary relief by thus enabling the crop to be marketed, but they provided little if any satisfaction owing to the poor appearance of the goods.

It was early apparent from results of preliminary experiments in Western New York by Hervey and Palm (1) and on Long Island that the limited employment of arsenical dusts was not likely to be successful owing to the necessity of having to omit treatments at an inopportune time in the programme of worm control, if excessive residues were to be avoided.

Autographa brassicae Riley, *Pieris rapae* L., *Plutella maculipennis* Curtis, *Mamestra picta* Harris.

Fortunately there were in 1933 two promising insecticides on the market, which had received the attention of a few entomologists because of their reputation for being non-poisonous to man when taken orally, namely derris and pyrethrum powders. Dusts containing these powders gave satisfactory results in preliminary tests, but owing to the high cost of pyrethrum powder (31 cents per pound) it seemed at that time more expedient that further trials should be restricted to the development of dusts containing derris, and later derris, cube and timbo powders. However owing to the urgency of the situation it was not long before rotenone—containing dusts were being used commercially on an extensive scale as a substitute for arsenical mixtures. The average brand of dust prepared locally contained clay as the diluent, and was formulated to contain 0.75 per cent rotenone strength.

During the fall of 1934 it was noted that certain growers were dissatisfied with the new dusts owing to their inability to obtain effective protection of the plants by dusting. The dust was blamed for the failure on the grounds that it was incapable of killing the larger larvae of the cabbage looper. It should be remembered that arsenicals have been generally employed successfully as a specific poison for all the different species of worms attacking crucifers, hence in the light of much of the information available at the time there seemed no reason to believe that rotenone-bearing powders were not capable of playing a similar role. Most of the difficulties experienced in controlling the cabbage looper had been attributed to peculiarities in feeding habits.

In order to obtain a clearer perception of the merits of rotenone-containing dusts as a means of checking worm injury, several series of insectary tests were run in which larvae of *P. rapae, A. brassicae,* and *M. picta* were exposed for 48 hours to the effects of derris powder sprayed on foliage. The results of each series of tests were noted at the end of a 96-hour period of observation, and they showed consistently that as a result of treatment mortality in the cases of younger larvae of *rapae* and *brassicae* was comparatively high, and in the case of older larvae of *rapae,* equally so. On the other hand the older larvae of *brassicae* seemed less affected by the presence of poisoned foliage, whereas the larvae of *picta* were largely immune and fed freely. In a complimentary series of tests with pyrethrum powder it was equally evident that a high percentage of the older larvae of *brassicae* and of the younger larvae of *picta* were capable of being killed when dusted lightly with mixtures of pyrethrum powder and clay. These results were later supported by data obtained in field experiments during the summer of 1935, in which there was a severe infestation of *brassicae.* In these tests plants dusted with pyrethrum mixtures were relatively well protected, whilst those dusted with rotenone-containing mixtures were seriously injured by insect feeding.

From these experiences it seemed inadvisable, at least for the present, to limit the search for an arsenical substitute to the development of rotenone products. It was evident that pyrethrum powder gave promise of being a valuable insecticide for cabbage worm control, and that it deserved further consideration despite the prevailing high prices.

The possibility of utilising pyrethrum powder as an insecticide in the vegetable growing industry was greatly improved during the fall of 1935 due to the sharp decline in cost of pyrethrum flowers. First grade pyrethrum powder containing .9 per cent pyrethrins was quoted at about 15 cents per pound. Prices continued at lower levels throughout the seasons 1936 and 1937. During this period additional experiments with pyre-

thrum products under field and insectary conditions had confirmed the results of earlier tests. They clearly indicated that pyrethrum dusts were more effective than rotenone-containing dusts for control of the cabbage looper, and were little inferior to rotenone-containing dusts for control of the imported cabbage worm. Under commercial conditions pyrethrum dusts had almost entirely displaced rotenone-containing dusts as a means of cabbage worm control. Much of the dusts was prepared locally. Mixtures usually contained a dusting grade of clay as the diluent, and were formulated to contain .6 per cent pyrethrin strength. So-called lower grades of pyrethrum powder containing .6 and .5 per cent pyrethrins respectively were also used effectively in an undiluted condition as dusts in the field. Contemporary investigations in Nova Scotia by Kelsall and Stultz (2) seemed to point to the same general conclusions, and to advocate a similar practice, although it must be admitted that dusts in use on Long Island for worm control contain about twice the insecticidal strength proposed as suitable for Nova Scotia conditions.

During the winter of 1937 - 1938 the market price of pyrethrum began to increase owing to conditions arising from the Sino-Japanese conflict. Pyrethrum powder of .9 per cent pyrethrin content was quoted at 24 cents per pound, and that of .6 per cent at 16 cents, prices which practically forbade the use of the material in vegetable crop production. Hence it again became necessary to reconsider other possibilities of meeting the arsenical residue problem. It seemed scarcely reasonable to expect to find an insecticide that would give such general satisfaction as pyrethrum powder.

It should be noted that during the period when pyrethrum dusts were placed on trial an additional series of tests was run in field and insectary with dusts prepared by the incorporation of powders that had been impregnated with a solution containing the extractives of pyrethrum. Such powders are sold on the market under trade names such as *Dry Pyrocide, Impregno, Activo, Activated "A" dust*. They may be described briefly as stock powders carrying concentrated amounts of pyrethrins in solution. Certain brands are standardized to contain a minimum strength of 2 per cent pyrethrins and others 0.5 per cent: some manufacturers make use of an extremely fine and porous grade of diatomaceous earth as the absorbent or carrying agency, and others the exhausted reground pyrethrum powder itself, after the commercial process of pyrethrin extraction has been completed. Such products invariably require dilution and conditioning as a necessary preliminary to their further use. Dusts prepared from such powders had given promising results as a means of combatting cabbage worms, but they were not regarded as equal in efficiency to dusts containing the ground flowers of pyrethrum.

Nevertheless during the spring of 1938 there seemed no better way of meeting the emergency than to resort to the employment of impregnated dusts. Many farmers returned to the use of rotenone-containing dusts, which were comparatively less costly. However during the current season so-called impregnated dusts have been employed locally on a large scale. They have received a mixed reception at the hands of growers. It is felt that in many cases the reasons for failure have been due to inexperience in handling this type of dust with the machinery available, rather than to any serious fault in the dust itself. Undoubtedly there is room for much improvement in the manufacture of such products and in their preparation as dusts, if they are to become a sound commercial proposition in the vegetable business.

In this respect it is apparent that great importance should be attached to the requirements necessary to ensure a thorough and efficient mixing of the ingredients in the preparation of dusts, especially where stock powders are used which exhibit a damp or "greasy" consistency. It has been found inadvisable to use fine grades of clay as a carrier for pyrethrins held in solution, possibly because of the absorbent properties of clay which may interfere with the proper functioning of the pyrethrins. Carriers such as talc have been satisfactory, and certain types seem more desirable than others on account of their superior physical properties. A small quantity of diatomaceous earth has been included in mixtures applied for experimental purposes in an attempt to improve their dusting qualities, since it has been found that some impregnated dusts tend to be too heavy and too "oily" for most effective use in many types of dusters as now constructed.

During 1938 impregnated dusts for cabbage worm control were formulated to contain a strength of 0.25 or 0.3 per cent pyrethrins. The fact that impregnated dusts may be used effectively at much lower pyrethrin strengths than pyrethrum dusts has been based on the grounds that in impregnated dusts all particles presumably tend to become active ingredients, as in nicotine dusts, and that in such dusts the pyrethrins are placed on the outer surface of particles where they are in a superior position to exert their insecticidal properties.

In conclusion it may be said that from our experiences on Long Island there is as yet no well sustained belief that insecticides of plant origin, such as pyrethrum, derris and related plants, will satisfactorily meet the permanent requirements of the present situation. Such insecticides have proven to be useful in an emergency, but they lack important qualifications that seem essential to further advancement, namely, marked toxicity to common chewing insects as a group, considerable resistance to deterioration, and inexpensive methods of production and manufacture.

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NOTES ON THE ARMYWORM, *LEUCANIA UNIPUNCTA* HAW. OUTBREAK IN ONTARIO IN 1938

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It is felt by Professor Caesar and the writer , both of whom had experience in the 1914 and 1938 outbreaks of the armyworm, that certain points in comparison should be recorded for future reference. These notes on various phases of the 1938 outbreak are offered for that reason.

Extent of Outbreak.—Although the outbreak in 1938 was widespread throughout Ontario, there were probably not as many counties with moderate to heavy infestation as in 1914. On the other hand, the areas of severe infestation were larger and more numerous in 1938.

Time of Occurrence.—The 1938 outbreak was decidedly earlier than that of 1914. In the latter year, the first report received in Guelph was on July 14 from the Burford area in Brant County, whereas the first report in 1938 received at Guelph was on July 6 from Pickering Township in Ontario County — one week earlier from a much later district. The Dominion

authorities in the meantime had dealt with a still earlier outbreak from the Niagara district which D. F. Patterson, of the Dominion laboratory at Vineland visited on June 30.

The outbreak of this year indicated a greater spread in time of severe infestation. For example, in a heavily infested field in North Brant pupation had entirely taken place, while in nearby Waterloo County active feeding was still continuing and control measures were still being applied. The same occurred in Victoria County and in other areas. In North Simcoe very heavy infestations were under way on July 15, and as late as August 8 fields were still being reported as heavily infested and requiring treatment. This would seem to indicate that not only was the outbreak earlier than in 1914, but the egg-laying flight seems to have continued over a longer period.

Crops Attacked—As in previous outbreaks only members of the Gramineae were attacked, but whereas in 1914 most infestations had their origin in grasses and injury in spring grain was due to migration, in 1938 the most serious injury occurred where infestations had their origin in spring grain itself. There were, in this year, numerous cases where eggs had been laid in grass and migration had taken place as in 1914, but probably in the majority of cases in 1938, the severe injury in spring grain was in cases where egg-laying had taken place in the spring grain crop. Hence the usual statement that, in the case of the armyworm, migration is from grassland areas was in 1938 only partly true. It is probable that the heavy egg-laying in spring grain in 1938 was due to the earlier time of the outbreak. This year a number of cases were noticed in which migration took place from winter wheat into spring grain, as the wheat matured.

Life-History.—Mention has been made above of the spring egg-laying in spring grain as compared with the general habit in 1914 of spring egg-laying in grasslands.

No fall egg masses were found in the field in 1938. Information seems to be meager with respect to the place of oviposition of the fall moths under field conditions. The eggs are usually said to be laid on the leaves of grass. Dr. G. M. Stirrett, of the Dominion laboratory at Chatham, Ont., reports that Messrs. Hudson and Wood in 1926 using couch grass in bag cages found most of the eggs laid on the leaf blades, largely in folded leaf blades. Our experience in the insectary this year and also an examination under field conditions in heavily infested areas would suggest that possibly the eggs under field conditions might be laid at the crown of the plants, or on or just beneath the surface of the soil, since egg masses were not found on the leaves under field conditions.

One interesting point in the life-history under 1938 conditions is that at Guelph we have secured over-wintering pupae in the insectary. This insect is, of course, supposed to winter in the larval stage. Again the early character of the outbreak may be a factor.

Natural Control—Braconid pupae, probably those of *Apanteles militaris* Walsh, were found in considerable numbers throughout infested areas. The tachinid *Winthemia* was not nearly so abundant as in 1914. In that year practically all larvae in the later stages of the outbreak carried *Winthemia* eggs, whereas in 1938 throughout most of the infested areas *Winthemia* parasitism did not exceed two to four per cent. An exception to this is the Niagara district outbreak where Mr. Patterson reports many

caterpillars carrying the eggs of *Winthemia*. Other parasites, including certain large *Ichneumon* flies, were also present, but not in the numbers of 1914.

Artificial Control Measures.—Where the larvae were migrating, deep furrows or trenches were used this year as in 1914. In many cases, however the furrows had to be made in fairly heavy soil and here it was found that the use of poison bait in the trenches gave improved results. Experience this year would indicate that, if a fairly good furrow is completed by three o'clock in the afternoon and poison baited by four o'clock, satisfactory results can be secured. After the larvae have made several attempts to climb the wall they apparently will turn their attention to the bait and feed earlier than they would in unhindered migration.

The heavy infestations in green spring grain as a result of the earlier outbreak and of egg-laying in spring grain brought about a new condition in control compared with 1914. Large scale poison baiting of thick standing crops of spring grain for armyworm had not been attempted in Ontario. An experimental field of a thick crop of barley was selected at Pickering and treated by broadcasting poison bran bait. Men were sent through the field about six feet apart and told to throw the bait forcibly toward the left and toward the ground to attempt to cover the area to the next man in line. Seven hundred pounds of bran, dry weight, were used on the 16 acre field. Practically 100 per cent. kill was secured. Poison baiting was then generally recommended in infested spring grain crops. The bait used was the standard Paris green, bran, molasses and water formula. It was found that to secure practicable control, 30 to 50 pounds dry weight of bran per acre were needed. In most cases, neighbours turned out in large numbers, and it was found that a gang of men could cover an infested field in the manner described in quite a short time.

The outbreak in Renfrew County was under the direction of the Dominion Division of Entomology and Mr. Gilbert reports that sodium arsenite used in baits there did not give good results, and that they relied entirely on Paris green. The writer did not have an opportunity to test poisons other than Paris green, but in one case in which white arsenic was used, good results were not secured. Accordingly, Paris green was generally recommended and used. It is interesting to record in connection with artificial control that in one case where an experimental area was heavily dusted with a nicotine dust by a power orchard duster, no mortality amongst the larvae was observed.

Possibilities of an Outbreak in 1939.—On the basis of past history of outbreaks in Ontario, we would not be led to expect any severe outbreak in 1939. It must be pointed out, however, that conditions in 1938 were certainly very different from those in 1914. In that year, *Winthemia* parasitism was practically 100 per cent; this year it was very low. In 1938 there was an extensive flight of moths in the late summer and fall. Numerous fall generation larvae were secured in the insectary in 1938 and none were secured in 1914. In 1914 there were no records of fall generation larvae in the field; this year we have at least one report from an infested area in Ontario of fall generation larvae in numbers. In this connection, R. P. Gorham, of the Dominion laboratory at Fredericton, N.B., reports numerous fall generation larvae in New Brunswick in 1938. It is interesting to note that these fall generation larvae followed the 1938 outbreak which had succeeded an outbreak in 1937. In this connection, Mr. Gorham says:

—"After the outbreak in 1937 we were reasonably sure from past history that there would be no further outbreak for some years, but the record of 1938 plainly showed we were wrong, and so far as I can see there is at present no reason to expect that we should escape another outbreak in 1939".

In so far as Ontario is concerned, we cannot be at all certain that there will not be an outbreak in 1939. I believe those of us working in this province should be on the watch for the spring moth flight and the possible appearance of early larvae.

Publicity.—The 1938 armyworm campaign provided an opportunity to make an interesting comparison with conditions aiding publicity as compared with those which were in effect in 1914. The automobile has completely changed the picture with respect to conducting a field campaign and special mention should be made of the radio as a publicity agent. This was used this year extensively, not only for the broadcasting of direct information in regard to control, but local radio stations were also used for hurry-up calls to farmers for field meetings in their districts.

THE 1939 OUTBREAK OF THE ARMYWORM IN QUEBEC

By GEORGES MAHEUX AND PELLERIN LAGLOIRE

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In the entomological history of Quebec, we have not yet found records of outbreaks of the armyworm (*Leucania unipuncta* Haw.), at least nothing so sudden and widespread as the one that occurred last summer.

Although generally well informed, the curious and successful searcher Leon Provencher makes no mention of this species in the *"List of Insects Injurious to Wheat"* he prepared in 1857. Yet, specimens of armyworms are present in almost all entomological collections we have examined. Heretofore we have been unable to find proof that this pest had been recorded as a serious enemy of field crops at any time since the foundation of Quebec.

Nevertheless, the armyworm bears all the marks of a native insect, enjoying a wide distribution but whose conspicuous manifestations are quite rare or accidental. Would it not be a case of a perfectly logical balance operating according to a regular rhythm which is being disturbed only as a consequence of extraordinary circumstances? To become suddenly a formidable pest there must be, of necessity, an ideal association of ecological and biological factors of very rare occurrence. It is no doubt due to such favoured circumstances that the armyworm suddenly became a very noxious pest last summer.

We are aware that some years ago the species worked havoc in some sections of Ontario. We also had personal experience with a local outbreak, in 1917, in the district of Temiscamingue. The same year another noctuid, the glassy cutworm (*Sidemia devastator* Brace), appeared in one locality in the Lake St-John section. From 1917 to 1935 our records show absolutely no mention of any damage caused by armyworms. In 1935, however, we began to receive from various settlements on the North Shore of the St-Lawrence River complaints against an insect causing much damage in vegetable gardens, and this insect was finally identified as the armyworm. In 1937, on the North Shore and in many centers of colonisation in the Matapedia Valley this insect appeared in large numbers and caused serious loss, but in both cases these were only local manifestations and we had every reason to believe that they were purely spasmodic.

With 1938 the situation changed suddenly. Excepting a zone in Southern Quebec extending from Montmagny to Compton, outbreaks of various importance were recorded from all districts and counties. The most important epidemics were suffered in the western and northern districts: Abitibi, Pontiac, Gatineau, and Lake St-John. Other outbreaks of less importance, but still quite troublesome, occurred in the districts of Temiscamingue, Papineau and St-Hyacinthe.

The following statistics clearly show the extent of the outbreak:

Area occupied and damaged	45,000 acres
Estimation of damage to crops:	$148,000.
Number of farmers suffering damage	3,250
Average loss per farmer:	$45.00
Approximate cost of control:	$12,000.
Approximate value of crops saved:	$350,000.

In every locality where we had the opportunity to study the development of the outbreak it seems that the armyworms pass the early stages of their development on weeds and forage plants growing in low lands, swamps, along ditches, and on the outskirts of woods, i.e., in places where the vegetation is never cut by the farmer because of its poor value and the difficulty of using the mowing machine or even the scythe. In such places there is enough food to maintain an unconspicuous colony of armyworms in normal years. With favourable climatic conditions and the corresponding recessions of their enemies, egg-laying and hatching reach a maximum.

During the first two instars this largely increased number of caterpillars devours all the food available in this food restricted place of birth and they are consequently forced to migrate. It is at this time that their legions may be seen invading the neighboring cultivated fields. From their center of dispersion they generally go towards meadows where plants kindred to their normal foods are to be found. Their presence and the resulting defoliations are not noticed by the farmer until the time of haymaking. With the cutting down of the grass in the meadows, the zone of dispersion widens and the armyworms now penetrate the other fields of cereals, corn or vegetables.

In most cases the defoliation is complete and even a notable part of the stems are destroyed within two or three days in fine weather. From a distance the fields appear like an immense old brush with its bristles irregularly worn out. Buckwheat, alfalfa and clover do not suffer any appreciable damage.

With the approaching transformation into pupae the caterpillars wander here and there and they may be seen crossing roads in columns 10, 15 and 20 feet wide. When surprised by cold weather or rain during their journey they sometimes gather in extremely large numbers along walls or in ditches where they form bundles up to six inches in diameter; hundreds may also find refuge under balls of earth.

The period of greatest activity lasts from two to three weeks, the length of the period depending upon the temperature favourable for feeding. In a province where climatic zones from south to north are quite pronounced the activity of the armyworms covered the larger part of the summer. The first outbreak appeared on the 29th of June in the County of St-Hyacinthe and the last one was reported on the 8th of August in the County of Bonaventure on the Baie des Chaleurs. The other outbreaks in different parts of the province took place between these two extreme dates.

There is nothing new regarding the control measures that were used this summer, namely: Poisoned bran, trenches, arsenical sprays, rolling and burning.. In general poisoned bran gave best results but a combination of these various means of control, according to the local conditions, was quite satisfactory. The control operations were directed by the local agronomists in co-operation with the agricultural organizations. In spite of the rapidity of the attack the organization for control was set up in a short time and yielded very good results. The Department of Agriculture supplied a great deal of material and also helped financially to meet the expense. The success of the fight is undoubtedly due to the perfect co-operation of the local agronomists with the men of the Plant Protection Service.

CONTROL OF THE HOUSE CRICKET

By L. Caesar and G. G. Dustan

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Early last August the senior author read in the press an account of what seemed to be a serious outbreak of the house cricket, *Gryllus domesticus* L., in Oshawa, and went down to investigate. The infestation clearly all came from one of the city garbage dumps about a mile south of the city and several hundred yards distant from any houses, except three or four. These, the city engineer said, were the only houses in which there was any appreciable infestation.

The dump was about 150 yards in length and about 15 feet deep. No crickets were visible on the surface, but when loose refuse was removed in the active parts of the dump, thousands of crickets in all stages of development, were revealed and with amazing agility, leaped away and disappeared. In some places there must have been 1000 or more to a square yard. In the inactive older parts of the dump, only an occasional cricket was found.

The fact that crickets were in all stages showed clearly that they were breeding in the garbage. Moreover, the fact that only the houses nearby were troubled by them seemed conclusive proof that they came from the dump. The occupants of the nearest and worst infested house situated about 120 yards away from the nearest active part of the dump, said that at nights thousands of crickets migrated along the roadway and a bank, from the dump to the cottage and its surroundings. Many of these entered the houses, while many others remained hidden by day outside in the grass and under various kinds of cover, a favourite place being an old carpet left for a time on the ground.

The house was inspected and was seen to be horribly infested. There must have been at least 2000 dead crickets on the floor, chiefly close to the walls, and several living ones on the walls. The dead crickets had been killed by a spray of what seemed from the odour to have been a creolin liquid. The woman stated that almost every morning for several days she had swept up just as many crickets as were present at the time of the inspection. She said that they were eating all kinds of clothing, got into the beds, and almost every place, and that unless something were done, they would have to abandon the house. She and her husband were foreigners, and probably, therefore, more patient than Canadians. It seems almost impossible that any Canadian would have tolerated such conditions for 24 hours.

The Oshawa Council were anxious to do what they could, but did not know how to meet the situation. Hence they welcomed the visit of an entomologist, even though he himself had never before had to deal with the pest. They were advised to cover the active parts of the dump to a depth of about 6 inches, with earth, slag, lime, or other similar material, after first burning as far as they could conveniently, all boxes and other bulky combustible material which would otherwise require a lot of covering. In the meantime, they were urged to deposit the garbage in the parts of the dump as far away as possible from the infested active parts. By rotating and covering the different areas in turn, and burning anything that would burn, it was hoped that the crickets would be unable to breed rapidly. The use of a sodium fluoride-bran-molasses-water bait was also recommended. The bait was suggested also for use in the infested houses.

Late in September, the region was again visited and the dump found to have been covered with earth and abandoned for another situated about a mile away. An examination of this old dump showed that there were only a few crickets to be found and these only where the covering had been poorly done. The heavily infested cottage was again inspected and was found to have scarcely a cricket in it. This house had been covered on every side with good lumber which overlapped and left scarcely any opening for crickets to enter. Galvanized iron sheeting had been sunk deeply into the ground and firmly nailed to the sills, to prevent access from beneath, then the cottage had been fumigated to destroy any crickets present. The occupants said that their troubles were at last over. In Oshawa sodium fluoride had been given a trial by order of the city engineer, who stated that it had killed many of the crickets, but was felt to be too costly, and therefore the dump had been abandoned and covered, as stated above.

In Guelph where there was a small outbreak, a test of a bait, in which Paris green was substituted for sodium fluoride, was made but seemed a failure, for no dead crickets could be found during the next five days. A heavy treatment was then made with the sodium fluoride bait outlined above, and after a few days, many dead crickets were to be seen and the infestation was apparently much lessened. No further outdoor controls were tried because it was now October and the cold would soon prevent any more trouble.

In Guelph a room in a cellar in each of two infested houses was treated. In the first, about 4 inches wide of the floor all along the walls was covered with a dust made of equal parts of sodium fluoride and pyrethrum powder. When examined three days later all the crickets were either dead or dying. In the other house, the room was first swept carefully to make sure all dead crickets were removed. Then a newspaper was placed in one corner and a ring of equal parts of sodium fluoride and pyrethrum powder laid down in the centre. This ring was about one inch wide and half an inch deep and enclosed an area about 8 inches in diameter. In the centre of this, an unpoisoned bait of bread, sweet cake and a slice of ripe apple was placed. It was felt that if this worked well, it would be a vastly cleaner and cheaper method than the other. When examined four days later the only crickets were 20, most of which were dead and the others dying.

Laboratory Tests on Control of Crickets.—After these initial tests, it was decided to run a series of controlled tests with sodium fluoride and pyrethrum powder respectively, and if time permitted, with a few other insecticides. These laboratory tests were conducted by the junior author.

Crickets were collected at the city dump late in October and kept in the laboratory in large jars partially filled with old rags and bits of paper, and kept supplied with water and food.. Several tests with a number of foods indicated that dry rolled oats was as attractive as any. The insecticide tests were made in wooden boxes, about 6x 8 x 10 inches, having wire screen tops. Food and water were supplied as needed.

The insecticides were applied in four different ways, and these are referred to in the following table as:—(1) *Layer method.* Here the crickets were allowed to run over a thin layer of poison about 1/32 inch thick for from one to two minutes, then transferred to a cage with unpoisoned food for observation. (2) *Ring method.* Here a teaspoonful of unpoisoned food was placed in the centre of the cage, and around this, at a distance of about three inches, was poured a ring of poison about ¾ of an inch wide and ⅛ of an inch deep. (3) *Spot method.* Here unpoisoned food was put at one or two places on the floor of the cage, and then a little of the poison put in one spot at another place on the floor, the object being to see if the crickets avoided the poison. The results showed that, under cage conditions at least, they did not seem to be repelled by either sodium fluoride or pyrethrum, but walked over the poison and were killed. (4) *Bait method.* Here the poison was mixed with the food (usually rolled oats) and placed in the cages with the crickets.

Records were kept of the daily mortality for period of a week or more for each test, but the data given here have been summarized to show only the percentage killed at the end of one day, four days, and one week respectively. It would seem reasonable to assume that any material which took longer than one week to give a complete kill would not be satisfactory.

The following table shows that both sodium fluoride and pyrethrum gave 100 per cent. kill in each test, when used by either the ring or spot methods. Some of the other materials also gave a complete kill in less than four days, but not enough tests were made to draw any conclusions from them. The crickets in the check cage lived for at least 23 days, after which time observations were discontinued.

TABLE 1.—SUMMARY OF RESULTS OF INSECTICIDE TESTS IN CONTROL OF HOUSE CRICKET

Material	Method	No. crickets	Per cent dead in less than— 1 day	4 days	7 days
Pyrethrum	(1) layer	14	43	78	100
"	(2) ring	10	100		
"	(3) spot	10	100		
"	(4) spot	10	x	100	
"	(5) spot	10	x	100	
Sodium fluoride	(1) layer	14	57	100	
" "	(2) layer	8	62	100	
" "	(3) ring	10	40	100	
" "	(6) spot	10	50	100	
" "	(7) bait	10	x	100	
" "	(4) spot	10	30	100	
" "	(5) spot	12	8	58	100
" "	(8) bait	12	x	33	100
" "	(9) bait	12	x	58	100
Sodium fluosilicate	bait	10	50	100	
White arsenic	(1) spot	10	50	100	
" "	(2) bait	12			16
Sodium arsenite	(1) spot	10	90	100	
Derris (powder)	(1) layer	14			16
" "	(2) bait	12		8	16
Thallium sulphate	(1) bait	10			40
Tartar emetic	(1) bait	12		40	70
Zinc phosphide	(1) bait	10	33	83	92
Check	no poison	10	none dead in 1 month		

x indicates that no record was taken.

Pyrethrum had a very quick initial action on the crickets, enfeebling them in less than one-half hour, although death took place much later. The initial action of sodium fluoride was considerably slower. Both materials usually gave a complete kill in less than four days. The bait method of using sodium fluoride was much slower in giving 100 per cent kill than either the ring or spot methods.

Control Measures Recommended.— (1) Wherever a city can afford to purchase an incinerator in which all garbage can be burned, it will have no trouble from crickets breeding in garbage dumps and entering private homes.

(2) If the city cannot afford an incinerator and if an alternative dump is available, the dump being used should be inspected once every two or three weeks to see if any crickets are present. If any are found, it should at once be abandoned and the other dump used for at least a month or until practically all the crickets have disappeared. As soon as the infested dump is abandoned, the garbage should be covered to a depth of at least six inches with earth, cinders, soot, slag, lime or other similar material. When the crickets have all, or nearly all, disappeared it may again be used.

(3) If there is no alternative dump, a great deal can be done to keep the crickets from increasing rapidly by (a) making a practice of separating all bulky combustible material from the rest of the garbage and burning it each day, (b) depositing all garbage for two or three weeks in one definite part of the dump and then for two or three weeks in another distant part, and the next few weeks in still another part. Each part, when abandoned, must be covered just as quickly as possible with the materials mentioned above to destroy the crickets .

(4) The last two measures may be supplemented by the use of a poisoned bait made as follows:—Bran 25 lbs., sodium fluoride 1 lb., molasses 2 qts., water 2½ gals. Dissolve the sodium fluoride in the water by stirring, add the molasses, stir again, and then pour the poisoned liquid over the bran and mix thoroughly until all the bran is well moistened. Mix with a shovel on a smooth board floor or on level cement. Apply late in the evening by carrying the bait in a pail and scattering it by hand heavily over all parts of the dump where there are crickets, and for a few yards on every side. If loose refuse on top is lifted and the bait thrown beneath, it will remain fresh and attractive in such places longer. Repeat in a week, and again a week later.

(5) To destroy the crickets in houses, sweep the house carefully. Then place a newspaper in one corner of each infested room. In the centre of this put a ring of dust made of equal parts of fresh pyrethrum powder and sodium fluoride well mixed together. The dust ring should be about 1 inch wide and heavy enough to cover the paper. The area enclosed by the ring should be about 6 inches in diameter. In the centre of this ring place a small handful of dry oatmeal and if the room is very dry and humidity low, place a teaspoonful of applesauce once every two days alongside the oatmeal. The crickets have to go through the dust to get at the bait and are thereby killed. Leave the bait and dust undisturbed until all crickets have gone. Then remove the paper with its contents and burn. To keep dogs and cats from the bait and poison, a pan or box may be placed over it and raised up on one side just high enough to allow the crickets to enter. The darkness from this covering will, in fact, tend to attract them to go beneath

Caution.—It should be remembered that sodium fluoride is poisonous, and hence should be kept in a corked bottle labelled "poison". See to it also that children do not tamper with the materials on the newspaper.

This ring method of baiting will also kill cockroaches. Moreover the measures recommended in 1, 2, and 3, will be found helpful in preventing the increase of cockroaches, house and other flies, and rats, all of which breed freely in garbage dumps.

THE MULLEIN LEAF BUG — *CAMPYLOMMA VERBASCI*, MEYER, AS A PEST OF APPLE IN NOVA SCOTIA

By A. D. PICKETT
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Although fruit growers and entomologists have suspected this mirid of damaging apples for the past several years, it was not until the present season (1938) that this point was established by definite information.

In 1913 Parrott (2) and Parrott and Hodgkiss (3) reported this insect as stinging pears in New York State, but regarded it as of slight economic importance. In 1919 Ross and Caesar (4) reported it as seriously damaging apples in two orchards in Norfolk County, Ontario. They stated that in some trees the injury ran as high as 75 per cent.

The insect is not new to Nova Scotia since we have specimens in the collection at the Agricultural College, Truro, taken in 1920 on potato at Kentville, N.S., which is in the centre of the apple producing section of the province.

The writer remembers that the late F. C. Gilliatt, of the Dominion Entomological Laboratory, Annapolis Royal, N.S. made many observations on this insect in 1925, and that it was very numerous in a number of orchards at Starrs' Point, Kings County in that year. At that time it was observed only in orchards where the green apple bug, *Lygus communis* Knight, was a serious pest, and its injury was probably mistaken for that of the latter insect. A number of authors have reported it as feeding on honey-dew in aphis colonies and Gilliatt (1) reported it as feeding extensively on the European red mite, *Paratetranychus pilosus* C. and F.

Normally the insect feeds on mullein, *Verbascum thapsus* L. and it has been reported as feeding on a number of other plants such as sugar beet, potato, catnip as well as apple and pear. In Nova Scotia nymphs of the second generation were found developing on the evening primrose, *Oenothera sp.*, and the woolly woundwort, *Stachys lanata.*

In Nova Scotia there are two generations each year. When first generation adults appear on apple they soon migrate to other plants, particularly to potato, which they sometimes injure seriously, causing a wilting and dying back of the new growth. The insects do not appear to damage mullein to any extent, since several hundred specimens may be taken from one plant which appears normal and healthy in every respect. Ross and Caesar (4) have described the typical injury as found on apples.

Damage to Apples in the Annapolis Valley.—The severity of injury varies greatly with the variety, although the insect may be quite uniformly distributed throughout the orchard. In general the varieties attacked were the same as those preferred by the green apple bug *Lygus communis.* However, the latter insect as a rule does not develop on varieties which it

does not damage, while in many cases, the mullein leaf bug will be as numerous on those varieties which are not stung as those that are heavily damaged. In one orchard where fairly careful observations were made the Ben Davis variety was badly stung, while another variety called Kitchener showed no injury whatsoever, even though the majority of fruit clusters contained five to ten nymphs each.

Also it was noted that there was some variation from orchard to orchard in respect to the damage to various varieties. For instance in one orchard the variety Baldwin would be heavily attacked while trees of Northern Spy would show very little damage, while in another orchard the condition would be completely reversed, the Northern Spy showing heavy damage, and the Baldwin only lightly attacked. It might also be noted here that similar tendency has been observed with the green apple bug, but the differences are not so marked.

A number of growers reported a considerable amount of damage to Cox Orange Pippin, while in other orchards the nymphs were noted in abundance in the fruit clusters of this variety, but were doing no apparent damage to the fruit.

In general it might be said that the severity of damage to the susceptible varieties in the descending order was as follows: Northern Spy, Baldwin, Ben Davis, Gano, Nonpariel, (Roxbury Russet) Stark, Gravenstein and Delicious. However, as pointed out earlier in this article, there were many exceptions.

The damage was very severe in many orchards. In one orchard examined 90 per cent of the apples on Gano were ruined. In a number of orchards running heavy to the Northern Spy variety, the crop was cut 50 per cent and much of the fruit left on the trees were culls on account of the stinging of this insect. One grower in whose orchard the damage was widespread, but not unlike that of many other orchards estimated his loss at 1200 barrels of apples on 75 acres of bearing orchard. Although an estimate of loss covering so many orchards as were effected can be considered little more than a guess, it is the opinion of a number of men employed on orchard extension work, that the damage to Annapolis Valley orchards this year (1938) from this pest could be conservatively estimated at 50,000 barrels of apples. This indicates the seriousness of the outbreak. It will be of interest to learn whether this insect continues as a pest of major importance in our apple growing areas, or will follow the precedent it has established for itself in New York State and in the Province of Ontario.

Preliminary experiments and the experiences of commercial growers indicate that the treatments recommended for apple bugs in general do not give satisfactory control.

(1) Gilliatt, F. C., 1935. Some predators of the European red mite, *Paratetranychus pilosus*, C. & F. in Nova Scotia. Canadian Journ. Res., Sec. D., Vol. 13, p. 37.

(2) Parrott, P. J., 1913. New destructive insects in New York, Journ. Econ. Ent., Vol. 6, No. 1, p. 64.

(3) Parrott, P. J. and Hodgkiss, H. E., 1913. The false tarnished plant-bug as a pear pest. N. Y. Agr. Expt. Sta., Bul. No. 368, p. 382.

(4) Ross, W. A., and Caesar, L., 1919. Insects of the season in Ontario. 50th Annual Rept. Ent. Soc. Ont., p. 96.

AN OUTLINE OF THE LIFE HISTORY OF THE HOP VINE BORER, *GORTYNA IMMANIS* GUENEE, WITH NOTES ON ITS CONTROL

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The hop-vine borer, *Gortyna immanis* Gn. (Noctuidae), as its name implies, is a pest of hops. The earliest reference to this insect in Canada is given in a description by Dr. C. J. S. Bethune (1) of a number of unidentified larvae taken feeding in the roots of hops in 1871 at Erindale near Toronto. This author unsuccessfully tried to rear the larvae, and accordingly gave no name for the insect. His description of the larva and its injury undoubtedly fit that of *Gortyna immanis* Gn. Dr. James Fletcher (2) in 1892 exhibited adults, larvae and pupae of this insect taken in Prince Edward County. The first record of *G. immanis* Gn. in North America, where according to the general concensus of opinion this insect is indigenous, is in 1867, Dodge (3) recording it in that year from Juneau County, Wisconsin. Smith (4) gives the northern United States from the Atlantic to the Pacific for its distribution. Hawley (5) states that in spite of the fact that moths have been taken in the State of Washington, no injury to the hop crop of the Pacific Coast is reported in entomological literature.

At the present time, hops are not extensively grown in Eastern Canada, the area of cultivation being restricted to about 125 acres around the village of Fournier 50 miles south-east of Ottawa in Prescott County. In this district, the cultivation of hops dates back some 40 years. When the hop vine borer first made its appearance is not known, but it has been recognized by the growers for the past several years as a pest of economic significance. It is always present in the yards every year to a lesser or greater extent. Cases of severe injury are usually restricted to new yards in their first bearing year. An explanation of this will be seen when the life-history is described.

As the cultivation of hops in Eastern Canada is not wide-spread, it might be interesting to give a short description of the plant and its method of culture as practised in the Fournier district.

The common hop, *Humulus lupulus* L. is a perennial herbaceous climbing plant, growing from an underground stem or root stock. Hop plants send out, near the ground level, "runners" which extend several feet. These are cut into pieces possessing two or more buds, and are used for propagation. They are commonly spoken of as "roots" by the growers, but are stems, not roots. The aerial stems, known as vines or "bines" die back to the ground each year. The main stems bear opposite lateral branches on which grow the pistillate inflorescence, the "hops" of commerce. The hop plant is commonly dioecious, rarely monoecious.

Hop cuttings are planted in rows eight feet apart, the plants being seven feet apart within the row. The first year potatoes or beans are

(1) Bethune, C. J. S., 1872. Insects affecting the hop. Ent. Soc. Ont. Vol. 2, pp 27-34.
(2) Insects exhibited by Dr. Fletcher at the annual meeting. Ent. Soc. Ont. Vol 23, p. 22, 1892.
(3) Dodge, C. R., 1882. The hop vine borer. Ent. Soc. Ont. Vol. 13, p. 19.
(4) Smith, J. B., 1884. U. S. Div. Ent. Bul. O. S. pp. 34-39.
(5) Hawley, I. M., 1918. Insects injurious to the hop in New York with special reference to the hop grub and the hop redbug. Cornell Univ. Agric. Exp. Sta., Mem. 15.

grown in between the hop plants and no attempt is made to procure a crop. In the autumn of the first year, cedar poles are placed in the ground, two to a hill. The following spring the roots are pruned and the vines are tied to the poles when they are about two feet high. Three vines to a pole are usually selected and the rest cut off. A second and some times a third tying are necessary to keep the vines trained up the poles. The hops are picked from the vines by hand and dried in hop houses. They are then pressed and shipped to the breweries.

Injury by *G. immanis* Gn. can be classified into four groups, (a) early injury to the tips, (b) boring in the vines, (c) outside feeding at the base of the vines underground, and (d) feeding in the roots. The first two types of injury on the parts of the plant above ground are not so important to the grower because they occur as a rule, prior to the last tying of the vines, when the final vines have not been selected, so that the injured vines can be cut out and the healthy ones left. The injury underground is more serious because at the time at which this takes place any injury to vine or root manifests itself by loss of crop.

The early injury to the tips of the hops is so characteristic that in New York State, where the hop vine borer and its work are well known, injured tips are designated as "muffle heads". The young larvae on hatching enter the tips in various places. They may bore in at the side, leaving a well defined hole, or crawl in between the leaves, feeding in the centre. This feeding causes the tip to become swollen and blunted. Some times the larvae enter at the base of the tip at one side, which with later growth causes the tip to bend over.

Fig. 1.—"Muffle heads". Typical injury to hop vines by early invaders of hop vine borer May, 1937.

All larvae do not enter the tips but bore into the tender shoots at any place that they can make entry. Usually this takes place near the surface of the ground. Their borings in the vines are similar to other stalk borers.

Fig. 2.—Injury to hop vine stem by hop vine borer

When the larvae leave the tips of the vines, the stems of the vines where they have been boring or nearby grass plants, they start feeding underground to a depth of about three inches. Here they frequently attack the vines at their base, partially or completely severing them. This causes the vine to become swollen around the injured portion. At first the larvae, when feeding underground, are to be found within three inches of the surface, but as the last instar is approached, feeding larvae are found six inches in the soil. Some borers make shallow grooves on the outer surface of the roots, but many work their way right into the core, boring in all directions. This injury to the roots is a serious matter, for it invariably weakens the hill for the next year and frequently causes winter killing.

The life-history of *G. immanis* Gn. is as follows:—The winter is passed in the egg stage. The eggs hatch in the spring about the second week in May, when the hop plants are just beginning to sprout and appear above the ground. The larvae hatching from these eggs make their way into hop or grass plants. Those in grass eat their way into the stem at ground level, working their way up and killing the central blade. They leave the grass at about the time other larvae leave the inside of the hop. At this time, the flowers are forming on the laterals of the hop vines. The larvae that feed on hops from the time they hatch, enter the plant in that part which is most readily available and easy to penetrate. This may be in the tips, or the vines, or sometimes they feed on the vine underground. When the larvae start feeding underground, the early instars are spent within

three inches of the surface. At this time, the larvae are conspicuously marked with old-rose red markings and these are characteristic up to the beginning of the fifth instar. But as the larvae get older, they bore downward and at the same time become lighter in colour, losing the conspicuous markings, till by the time they enter the sixth instar, they are a dirty white

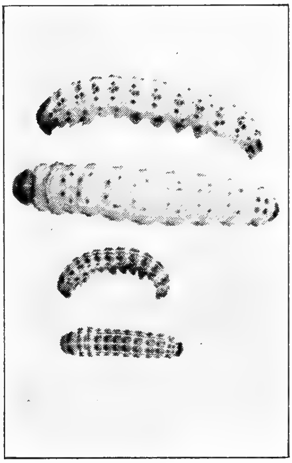

Fig. 3.—Fifth (right) and sixth (left) instars of the hop vine borer (natural size).

in colour and are to be found six inches below the surface of the soil. In the latter part of July and the first of August pupation starts. The pupae are formed in the ground amongst the hop roots as a rule three to four inches from the surface, but sometimes they are deeper in the soil. The pupae vary much in size, from 27 to 33 mm. in length. This variation is in no way correlated with sex. The pupal stage lasts about a month; the adult moths start emerging about the end of August, just about the time the hops are ready to pick.

The moths are light brown, with greenish or pinkish reflections in certain lights, with a wing spread of 40 to 51 mm. They are night flyers, hiding during the day in the grassy headlands of the hop yards or under piles of poles or vines which are left around the yards during picking.

Fig. 4.—Egg mass of the hop vine borer, freshly laid (right) and in following spring (left)

The females deposit their eggs in masses almost entirely on the weed grass, green foxtail (*Setaria viridis* L). The egg masses are most frequently inserted between the leaf sheath and the stem of the last internode. An average egg mass contains about 50 eggs. These are arranged most commonly in a double row fastened together with a sticky matrix which shortly after oviposition becomes dry and skin like.

The eggs are yellowish-white when first laid, but later turn to brownish-pink. They are 0.65 mm in diameter and 0.43 mm thick, flattened top and bottom. A female moth lays on an average 1500 eggs.

According to Hawley (loc. cit.) *G. immanis* Gn. is able to reach maturity only on hops, but he states that there is evidence of the possibility of other host plants. In the author's investigations other host plants have

not been found, but in 1938 he was shown some larvae and adults not distinguishable morphologically from *G. immanis* Gn. which had been reared on corn, on Isle Jesus where they had caused a certain amount of damage to this crop. Not a great deal is known about this occurrence of another host plant and it is not known whether these larvae would feed on hops. It is hoped that this point can be investigated presently.

The most obvious method of control that presents itself is a cultural one. If at the time of oviposition, that is just prior to picking, the yards are cleaned of all the weeds, then the ovipositing females will deposit their egg masses in the headlands where they may be easily destroyed, either by burning or spraying with crude oil, or other such methods. However, this is not as simple as it may seem. Reference was made earlier in this paper to the fact that the young yards in their first bearing year usually suffer the most severe injury. This is due to the fact that these yards are not free of weeds at the time of oviposition. The eradication of the weeds in the yards is not a simple matter. It is the common practice to plant hop cuttings in turned down sod in the spring of the year, planting potatoes or beans between the hop plants. This makes eradication of weeds more difficult, especially as twitch grass, a grass on which egg masses have been found besides green foxtail, is a common weed in the district. Care must be exercised in pulling out this weed, because if weeded very close to the hop roots, the latter are apt to be loosened in the ground, increasing the chances of winter-killing.

To secure a clean first year hop yard, the method of planting out the new yard might easily be altered. The ground set out for the yard might be summer-fallowed till mid-summer and then planted to buckwheat and the hop plants not set out till the following year. This, of course, is recognized as an added expense, but some of this expense would be off-set by the crop of buckwheat taken off the land. If new yards suffer as severe injury as one or two yards that have been seen in the Fournier district in the past two years, the growers will have to modify their method of setting out hop plants so as to ensure that they are free from weeds when oviposition starts.

Several insecticides have been tried against the borers in the roots, but with little success. Hawley (loc. cit) tried tobacco dust, tobacco dust and sulphur, hellebore and lime, hellebore alone, arsenate of lead and sulphur, black leaf 40, carbon disulphide and several others, with no success. He started preliminary experiments with paradichlorobenzene using a few crystals to a hill and from his results was led to believe that this soil fumigant showed promise. Accordingly this season (1938), the author set out a fairly extensive test plot of half an acre of hops, rented from one of the growers at Fournier to determine the effect of paradichlorobenzene on hop plants.

The plot was so laid out that the effect of the rate, depth, time and frequency of application of the insecticide could be checked. The rate of application was 5, 10 and 15 grams per hill, the depth 1, 3 and 6 inches, the time; early, mid and late season; and provision was also made in certain plots for two consecutive applications in the early and mid season.

The first application of paradichlorobenzine was made on May 9. The plants were examined weekly till the second application on June 6. At this time, no injury from the insecticide was evident. A week after the second application, a great deal of injury was apparent which manifested itself in the form of dead and dying vines and a certain amount of root

injury of the appearance of a watery rot. Where 15 grams per plant had been applied, injury as high as 44 per cent was noted and with 5 grams, from 12 to 22 per cent.

The fact that the first application did not injure the hills but that the second did, might be explained by the fact that (1) the temperature of the soil was higher when the second application was made and (2) that the hills had been hoed and the roots pruned just prior to the second application. The latter would present a quantity of damaged plant tissue in the root system of the plant which would likely be more easily affected by the material than would healthy tissue.

In those hills where two consecutive applications were made, injury was far more extensive, treatments with 10 and 15 grams per hill showed 100 per cent injury. The 5 grams per hill even gave as high as 50 per cent injury. In the light of this high percentage of injury, even from as small an application as 5 grams, it was decided that paradichlorobenzene is not practical as a soil fumigant for use with hop plants.

REPORT ON A TEST OF TARTAR EMETIC AS A CONTROL FOR THE GLADIOLUS THRIPS

By W. G. MATTHEWMAN AND A. G. DUSTAN

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In 1937 and 1938, R. H. Nelson of the United States Bureau of Entomology and Plant Quarantine experimented with tartar emetic sprays against the gladiolus thrips, and found a sweetened tartar emetic solution to be cheaper, equally effective and less injurious than the Paris green and brown sugar formula commonly used by gladiolus growers. The formula of the new spray is:

Tartar emetic—	2	ounces
Brown sugar—	8	ounces
Water—	2½	gallons (Imperial).

The first application was made when the foliage was six inches tall, repeated weekly for six weeks and discontinued about a fortnight before the blooming season. Enough material was applied to cover the foliage with fine droplets, but not enough to wet the leaves completely.

The tartar emetic and Paris green sprays were tested at Ottawa this summer, and the results of our experiment confirmed the findings of Mr. Nelson. Tartar emetic proved slightly more effective than Paris green and caused no noticeable spotting of the foliage. Both sprays were applied to quadruplicate plots of heavily infested gladioli five times in the month directly preceding blooming. The relative amounts of thrips' feeding scars present on the gladiolus petals was recorded, and the bloom was classified into two categories according to whether the flower spikes were "unsalable" or "salable". On this basis, the control obtained was 91 per cent with the Paris green spray and 97 per cent with the tartar emetic.

While the amount of poison in the Paris green formula is only one-half that contained in the tartar emetic formula, the amount of sugar is three times as great; consequently the tartar emetic spray is somewhat cheaper. Tartar emetic has the added advantage of complete solubility in water. The most important feature of the new spray, however, is that it does not burn the foliage.

PRESERVING INSECT SPECIMENS AND PREPARING MATERIAL FOR DISPLAY

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Barber's Method.—Any insect which can be placed in a preserving fluid without injury may be treated and preserved by Barber's method.

The following is a brief outline of Barber's method:

1. Kill in 80 per cent alcohol to which benzol, carbon bisulphide or some other fat solvent has been added at the rate of one part of solvent in 10 parts of alcohol. Allow the average specimen to remain in this fluid for at least 24 hours; larger insects and those with softer bodies should remain for 72 hours.

2. Change to 95 per cent alcohol and leave in this fluid for 24 to 72 hours, depending on size of insect.

3. Dehydrate in absolute alcohol containing a piece of limestone to take up moisture.

4. Transfer to xylol and dry on plaster blocks. Large specimens may be punctured to facilitate dehydration.

Larvae of most caterpillars preserved by this formula can be mounted on pins.

Alternative Preserving Method. — Boil for one-half to one minute in water, remove and pickle in alcohol solution — placing the specimens in 40, 60, 90 and 95 per cent alcohol for 24 hours each. Finally, put in xylol, then pin and dry.

Boiling soft skin will cause it to harden and the immersion in alcohol solutions will preserve ganglia, etc., while xylol assists in drying. After this process, a specimen may be pinned like any hard-bodied insect.

The author has found that this method preserves the larvae of May beetles and Japanese beetles better than Barber's Method. Do not boil scarab larvae too long or they will suddenly deflate and resist all attempts to bring them back to natural appearance.

Best results can be obtained by using absolute alcohol following 95 per cent in the above formulas.

Dehydrate Alcohol.—Absolute alcohol is too expensive for many amateur technicians and 95 per cent does not give the desired results. By the use of anhydrous copper sulphate the water can be removed from alcohol.

Heat inexpensive copper sulphate in a pan, until the water is driven off—or until the copper sulphate becomes white. Place this in your receptacle for alcohol. It will turn blue again as it picks up water.

By repeated heatings the alcohol may be kept almost completely dehydrated. About one third of the container of alcohol should be kept filled with crystals.

Staining Larvae.—Many specimens will be bleached after running them through either preserving method outlined, especially the greens, reds and yellows of immature stages.

I have had very good results with artificial coloration. Take an oil paint that is soluble in xylol and transfer the specimens from the xylol stage to the stain and leave in this solution two or three hours. Hymenopterous larvae as the currant saw fly and most Lepidopterous forms as the loopers can be taken from xylol, dried, and then immersed in the stain. Be sure and have the stain quite concentrated with pigment and shake before immersing the specimen. The xylol will immediately pentrate the larva and, of course, will carry the oil paint in the solution.

Smooth-bodied and oily specimens as larvae of colorado potato beetles will not take a stain and the coloring has to be done with a small brush using concentrated paint thinned with xylol.

Although I have not tried it, I imagine turpentine could be used as a clearer for those paints which are best thinned with turpentine.

Warning—Do not attempt to use water colors as the specimen will shrivel and become distorted immediately if it comes in contact with water.

Formalin Preserves Insect Colors.—While visiting the Staten Island Museum the author saw the remarkable preservation of browns and greens in cicadas and Orthoptera. Mr. W. T. Davis who prepared the specimens has this to say about the use of formalin—"The green color is much better preserved in the insects soaked in formalin with about 15 to 18 parts water for a few days than it is in the specimens not so treated. Insects can be placed in the formalin which after a few days can be poured off, the cork to the bottle replaced, and the insects brought home in a moist condition. If the mixture does not include too much formalin—that is, if it is not too strong—they will remain pliable and may be stretched and the legs arranged as if they had been dead but a few days. As requested, I am sending some specimens. The Orthoptera, you will note, were treated in the years, 1912, 1924, and 1927, and the green color is well preserved. I also include four specimens of *Tibicen chloromera.* If after 11, 14 and 26 years the insects still retain their natural green — it is surely worth while to treat them with formalin when first captured. The brown *neocenocephalus* was treated in 1912."

Specimens collected as long as 25 years ago still retain their color as if freshly caught. Specimens untreated discolor and turn dark brown within a short time.

Formalin-Chloroform for Preserving Reds, Yellows and Browns.—A 10 per cent solution of formalin saturated with chloroform has proven very satisfactory in holding the reds, yellows and browns usually lost in preservative. Take a vial of 10 per cent formalin and pour in an excess of chloroform. Shake the bottle two or three times a day for a week. Pour off the saturated solution and add the specimens. This worked best on the red and yellow of snakes and all shades of browns of ticks, and it should be applicable to insects. The specimens are, of course, left in the solution.

Preserving Small Soft-Bodied Insects.—Recently we had the pleasure of visiting David G. Hall at the Smithsonian Institution. After examining specimens he had prepared, we were surprised to learn that they had been placed in a preserving solution. Our attempts at pinning Diptera from solutions had not been very successful. We are sure our readers will ap-

preciate the formula used by Mr. Hall, described in the February, 1933, issue of *Entomological News.*

"When specimens of midges are killed and kept in a dry pill box, or placed immediately on card points, they do not retain the normal shape. When they are preserved in alcohol, they do not retain the pollinosity and color pattern. This formula was found to satisfy our requirements in preserving these small Diptera:

Alcohol, ethyl, 95 per cent.	85 cc.
Formalin, 10 per cent	15 cc.
Glycerine	5 cc.

"Living or newly killed specimens are placed in the solution and are allowed to remain in it as long as one desires. This period should not be less than 24 hours. The solution serves as a preserving fluid or as a treatment for specimens preparatory to mounting them on tips. When pinned specimens are desired, it is necessary to dehydrate them by placing them successively in 85 per cent, 95 per cent, and absolute ethyl alcohols, and xylol, allowing a full ten-minutes in each change.

"Instead of transferring the specimens with forceps or a camel's-hair brush, we find it satisfactory to use a small tip pipette in draining off the solutions. In this way the changes of solutions are made in one vial. During the process of clearing in xylol the specimens are given a normal position on folded strips of filter paper, so that the wings are in contact with the paper. The specimens and paper are gently removed from the solution and allowed to dry. The specimens are then mounted on tips in the usual manner."

The one disadvantage of this method is that the formalin used causes the chitinous portions of the male genitalia to become very hard; after such treatment they are difficult to boil in caustic potash.

How to Inflate A Larva.—Cut around the anal opening of the larva so as to free the rear end of the alimentary canal from the body. Lay the larva on a smooth soft absorptive surface, as blotter or paper towelling, and gently roll a round pencil or some such object from the head to the rear. If this is carefully done practically all of the body contents may be squeezed out of the rear opening without breaking the skin.

A glass canula should then be inserted until the clips can be fastened to hold the larva firmly in place. Some sort of an oven is now necessary. A home-made one may consist of a tin can supported over the flame of a candle or small lamp. Our special inflating oven which gives an even distribution of heat may be placed directly over a gas flame or electric grill. If used exclusively over grill or gas plate, remove legs and place bottom of stove close to source of heat. Air is then blown into the body of the larva. This may be done with the mouth or with a small hand bulb, but in any case great care must be taken that no more pressure be applied than is necessary to just distend the skin to its natural proportions. While this is being done the skin is held in the warm oven and turned constantly. As a result it will dry in its normal shape and size inside the warm oven.

As soon as the larva holds its natural position upon release of pressure it is ready to be removed. It is better to have the anal opening slightly flexible and moist. When removed in this way it can be handled without danger of crushing. A piece of balsa or other soft wood is inserted in the opening and when it dries the slight shrinkage holds it firmly in place.

Shellac or other adhesive applied to the base of the anal opening insures permanence of the fastening. This insect block may then be used as a means of handling the skin, and the pin on which the specimen is mounted may be thrust through this projecting bit of support and safely fastened to it with shellac.

The spring clips are best fastened to the tube by means of silk thread which will withstand the heat. Rubber bands are not as satisfactory for holding the clips in place but may be used.

Sealing Ligature Tubes For Permanent Preservation.—We have seen life-histories and specimens sealed in ligature tubes at Iowa State College and briefly outline the procedure:

1. Put specimens in ligature tubes.
2. Add alcohol or formalin and a snug plug of cotton. To avoid air bubbles saturate cotton before inserting plug in tube. A series of cells can be made with these plugs and the various stages held in these cells.
3. Let set overnight to completely saturate cotton plug and avoid bubbles.
4. Pour off excess preservative (formalin or alcohol).
5. Seal with blast lamp. A jet of flame from a blast lamp must be used as the regular bunsen burner does not have a small enough jet of flame. Of course, allow the tube to set a few minutes after pouring the solution off the plug or it will splinter when heated. Glasses should be warm to avoid splinters of glass as an occasional vial will crack.

Specimens so prepared can be examined from all sides and the mount is permanent.

Avoiding Bubbles in Vials.—A shipment of mosquito larvae was recently received and several of the respiratory organs were damaged. This was caused by a bubble in the vial which agitated the specimens as the package was shaken in transit. The troublesome bubble can easily be avoided by:

1. Taking a small rectangular piece of good quality absorbent cotton.
2. With the fore finger of the right hand twist this between the thumb and fore finger of the left. A blunt plug will be formed with the loose strands pointing away from the point of the plug.
3. Saturate this plug with alcohol.
4. Insert the moistened cotton plug into the specimen vial which should be full of alcohol.
5. Fill the space above the plug with preservative and insert the stopper.

The plug should fit the vial snugly and should a bubble appear between the cork and plug it cannot reach the specimens which will merely sway gently when shaken.

Formula For Preserving Plant Material.—We have seen specimens placed in this solution and recommend it for preparing injurious work of leaf-eating and tunneling insects:

Glycerine	50 parts
Acetone	25 parts
95 per cent Alcohol	25 parts

After remaining in this solution two or three days the specimen can be removed and dried. A plant specimen prepared in 1932 still retains a bit of green and remains pliable. Specimens so prepared can be passed out for examination in the classroom and laboratory.

Wing Mounts on Library Cards.—Last Christmas, Mr. Harry L. Johnson from South Meriden, Conn., sent me a card consisting of butterfly wings fastened to a small card which in turn was glued to an artistically prepared background. He writes as follows in response to my inquiry on his procedure:

"I am a bank teller by chance and we use a type of tape known as Scotch Cellulose Tape manufactured by Minnesota Mining and Mfg. Co. of St. Paul, Minn. I happened to think that with this I might safely mount the wings of moths and butterflies and so experimented. I have had these mounts a year now and they have retained color well. My idea is a safe mount and a handy one for the showing of common forms easily identified without recourse to genital characters, etc. for school use and the like. Mount could be used to show different types of insect wings, legs, antennae, etc., and the cards can be filed in an ordinary cabinet without danger from pests. The cards also allow the use of a specimen with but one set of perfect wings and dry specimens can be used about as easily as fresh ones. I use a razor blade to cut off the wings and put a bit of glue on each wing where it joins the body so as to keep it stuck in the right position on the cardboard while I am applying the tape. One must be quick to put on the tape, otherwise the wings will warp toward it and cause distorted specimens. As the tape comes up to two inches in width you can cover almost any specimen with a single piece although I prefer to lap the smaller tape when mounting larger specimens as the 2 inch width is rather awkward.

"The advantage of mounting the insect first on a small piece of cardboard and then attaching to the filing card is simply neatness and also a saving of filing cards if you damage a mount. You see this tape is so sticky that you can't make a good neat job of mounting directly on the filing card but by using any old piece of good white, fairly thin cardboard for the first mounting, you can then cut artistically around same and make a neat mount by attaching to the second or file card. There may be a better way than this but I haven't been able to develop it.

"I think the best application of this mount would be for school work where sets of wings could easily be used for identification purposes on the commoner material and also series of mouth parts, legs, wings, etc. of different insects could be mounted in this manner for easy identification and study by students. It also makes a very useful mount to use when you have a specimen of moth with only one set of good undamaged wings which you want to preserve.

"I have had these mounts made up for about a year now and they have not discolored, so figure they will keep in this manner indefinitely and should be completely protected from insect pests working on specimens in collections."

THE VALUE OF PREDATORY BIRDS

By W. E. Saunders, *London, Ont.*

On the programme of the 75th Annual Meeting of the Entomological Society of Ontario, there was included an article on the grasshopper plague in Manitoba, and am sorry that I did not hear this paper and have an op-

portunity to comment on it, for the reason that my own hobby of Ornithology bears strongly on such a subject. When I first visited Manitoba in 1892, no one could fail to be struck with the vast number of hawks to be seen. Now there is always a good reason for the concentration of any particular group of birds. They are mobile, and follow the best supply of food, and in that instance, grasshoppers, mice and gophers were doubtless the attraction, for a large proportion of our predatory birds make their predations on these forms, and one of these, the so-called sparrow hawk, which seldom touches a sparrow—never if grasshoppers are procurable—feeds almost entirely on those injurious insects. These various species have been ruthlessly killed by the gunners, whose prevailing and utterly erroneous obsession is that all the birds of prey are the enemies of man and should be killed, and this course of action has led to a great deal of disaster for the farmer. If the Manitoba prairies had now the hawks that they once had, it is very doubtful if grasshoppers would ever have become more than a minor nuisance to the residents, and I am informed that now (about fifty years too late) Manitoba gives those birds complete protection, but I have not learned that any special propaganda have been put forth in their interests.

Residents of Ontario have no great reason to criticize Manitobans, for protection is given here to hardly any of our predatory birds. The leader on the Black List is the great horned owl, the greatest mouser of all our birds. Every hawk and owl eats mice, but none take them in such quantity as this owl. To visualize his usefulness and value we need to consider the mouse itself. It seems almost too small and too trivial to be worthy of consideration, and it has been estimated that a mouse might do two cents worth of damage during its lifetime; but the danger that lies in mice depends not on their size but on their ability to reproduce. Dr. Vernon Bailey, of Washington, D.C., undertook to determine the rate of multiplication of the common field mouse, and procuring a healthy pair, he kept them comfortable, happy, clean and well fed for a year. The female soon began reproduction and for twelve months she had a litter, averaging six, every twenty-one days. Now, anyone could divide twenty-one into three hundred and sixty-five, multiply the result by six, and get the answer. But that is not the sum; for when the little females were forty-five days old, they too began to add six mice to the total every twenty-one days, and so did their daughters, and grand-daughters and so on. Bewildered by the vastness of the problem, Dr. Bailey gave his figures to an accountant, and said to him "At this rate, with no deaths, how many mice would there be from a single pair in a year?" The accountant sat down and did some figuring and at length looked up and said, "Dr. Bailey, in round numbers, there would be a million". Think of a million in one year from one pair! And the great horned owl is our very best preventive of this million. The late Robert Elliott, of Bryanston, had such an owl brought to him, dead, and on examining it he found that it had swallowed the skulls and bodies of thirteen field mice during the previous night, and if those mice were valued at two cents each, then that owl was worth twenty-six cents a day to that neighborhood, and that amounts to nearly a hundred dollars a year. If that figure were cut in two, and again in two, it would leave the owl still worth twenty-five dollars a year, and if the bird took four turkeys partly grown and worth, perhaps, ten dollars for the four, the question arises, would it not be worth while to pay the owl ten dollars for twenty-five dollars of service? The answer seems to be obvious, and yet that bird has no protection from the gun. It seems that Ontario needs a committee of students of nature to form our laws relating to wild life, and if that were done, this anomaly would cease.

A SUMMARY OF THE INSECT PEST SITUATION IN CANADA IN 1938*

By C. R. TWINN

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FIELD CROP INSECTS

Grasshoppers again occurred in outbreak numbers in the Prairie Provinces during 1938 and serious infestations continued in many parts of British Columbia. The most important species involved in these outbreaks were the lesser migratory grasshopper, *Melanoplus mexicanus* Saus., and the roadside or clear-winged grasshopper.

Camnula pellucida Scud. In Eastern Canada increased grasshopper abundance and damage occurred locally in Ontario and in the Three-Rivers, Montreal and Eastern Townships districts of Quebec Province. Further details concerning the outbreaks in the Prairie Provinces follow:

In Manitoba, grasshoppers continued to be of relatively minor importance. However, the light outbreak in the south-western portion of the province increased somewhat over that of 1937, and was augmented by rather heavy migrations from North Dakota and Saskatchewan. Consequently in spite of the effects of predators, which increased markedly during the year, a more extensive infestation may develop in this region in 1939. In Saskatchewan, grasshoppers again caused greater crop loss than any other insect pest, and increased their range somewhat, so that practically the entire agricultural area of the province was affected. The amount of crop dectruction was comparable to that experienced in the very heavy outbreak year of 1933, and was caused to a large extent by adult grasshoppers, much of it following migrations into districts where little or no loss had previously occurred. The intensified outbreak was due to the comparatively negligible mortality from natural causes of eggs and nymphs and to extensive migrations of adults locally and from the United States.

Furthermore, control work was hampered by conditions resulting from the general, extreme drought of 1937. In Alberta, the severe outbreak continued, the grasshoppers being very abundant in many scattered localities, with lesser numbers occurring generally over most of the province south of Edmonton. Stimulated by excellent crop prospects, farmers spread much poisoned bait, with the result that threatened major losses of crops were reduced to comparatively small proportions.

The mormon cricket *Anabrus simplex* Hald., which hitherto has not been of economic importance in Canada, in 1938 became sufficiently abundant in sections of Saskatchewan to cause apprehension, especially in the more southern parts of the province. The species was present throughout the entire prairie area and some distance into the parkland zone as far north as Unity, Rosthern, Humboldt and Stockholm. In some districts abundance almost reached economic proportions, so that with favourable conditions next summer control operations may be required against it. Small numbers also occurred in Manitoba, in the Pembina Mountain region north of Morden.

*Prepared at the direction of the Dominion Entomologist, from regional reports submitted by officers of the Division of Entomology, and members of the Entomological Society of Ontario. The original reports will appear in mimeographed form in Volume 17, of the Canadian Insect Pest Review.

The pale western cutworm, *Agrotis orthogonia* Morr., continues to be one of the most important crop pests in the prairie region, and in 1938, occurred throughout three-quarters of the agricultural area of Alberta and Saskatchewan. In the southern part of the latter province the severe drought of 1937 undoubtedly played an important part in reducing infestations and subsequent crop damage. The most serious crop losses in Saskatchewan in 1938 occurred just south of the northern fringe of the infestation, from Lloydminster to Prince Albert and as far south as Wilkie. Scattered and localized outbreaks of considerable severity also occurred in central, west central and southern Saskatchewan, with heaviest losses at Gull Lake. In the area between the South Saskatchewan river and Swift Current, losses were slight, and in the extreme south heavy precipitation during the period of larval activity rendered losses negligible. In the extreme north and east portion of the infested area dry weather resulted in heavier than normal losses from light infestations, and indicated that the outbreak would extend considerably further east in 1939. In Alberta the most severe damage occurred in the northern portion of the infested area, where the spring season was dry. Over much of the infested area the application of recommended cultural control practices, and, in some sections, abundant rainfall greatly reduced crop losses.

The red-backed cutworm, "*Euxoa ochrogaster* Gn., and its allies were of relatively little importance in Saskatchewan in 1938 although, as usual, they caused considerable damage in gardens. Even in the extreme northeast, where damage occurs almost every year, very little loss was reported. In northern Alberta, however, including the Peace river district, a severe outbreak of the red-backed cutworm developed over a large area. Damage was confined almost entirely to barley and oats seeded after a wheat crop in the previous year and extensive reseeding was necessary. This outbreak appears to have resulted from unusually dry weather in the spring and early summer of 1937. Apart from the usual cutworm depredations reported locally there were no important outbreaks of species other than those already mentioned.

The armyworm *Cirphis unipuncta* Haw. continued in outbreak numbers throughout Canada from Manitoba to the Atlantic seaboard. It was much worse and more wide-spread than in 1937 in Ontario, Quebec and Prince Edward Island. It was present but less widely destructive in New Brunswick, Nova Scotia and Manitoba and though recorded from Saskatchewan was of little economic concern.

In Saskatchewan wireworms, *Ludius aeripennis destructor* Brown and minor species, caused greater commercial losses to small grains than in any year on record, and potatoes and garden vegetables were also severely attacked and virtually the entire agricultural area was affected. The most severe losses continued to occur over the open prairie, where fully one-fifth of the total grain crop was destroyed by wireworms, with almost as severe losses in the northwestern park and forest area. Severe damage to grain seeded on land cropped previously was very common, and is apparently largely the result of the drought of 1937 having so completely prevented growth on cropped fields, that these fields reacted more like fallowed fields when seeded last spring. Vegetables and potatoes were very heavily damaged by wireworms, notably at Battleford and Saskatoon. In Alberta, similarly, although there probably was no great increase of wireworms, the loss of crops caused by these insects was greatly increased by the nature of the weather and cropping conditions of the season. Some records of serious losses were received from Manitoba, notably one field

at Souris which was completely ruined by these insects. In Ontario and Quebec wireworms were less injurious than usual.

Scouting work carried out in 1938 to check on the distribution of the potato psyllid, *Paratrioza cockerelli* Sulc., indicated that this insect has spread out rather alarmingly since 1937. It is now found in practically all sections of Alberta and Saskatchewan where potatoes are grown and last summer was recorded for the first time in British Columbia. It was found in the East Kootenays, probably having flown in from Alberta by way of the Crow's Nest Pass. The widespread distribution of the psyllid may possibly have been caused by an abnormally extensive migration into Canada from infested areas in the United States.

Blister beetles of several species, including *Lytta nuttalli* Say, *Macrobasis subglabra* Fab., and *Epicauta maculata* Say, were abundant in the Prairie Provinces and parts of British Columbia during 1938. Caragana, beans, peas, alfalfa, potatoes, mangels and other garden crops were attacked. In many sections the feeding of these insects interfered considerably with the successful establshment of caragana shelter belts.

Root maggots generally were less abundant throughout the Dominion in 1938 than has been the case for some years. In parts of Ontario where the onion maggot, *Hylemyia antiqua* Meig., is usually a pest of considerable importance, little injury was noticed. The cabbage maggot, *Hylemyia brassicae* Bouche, was reported as scarce in Ontario and New Brunswick, but in Quebec was more abundant than in 1937. This insect is annually becoming more of a pest in turnips, particularly in Eastern Canada. The carrot rustfly, *Psila rosae* Fab., typically a pest of Eastern Canada, caused serious losses in New Brunswick where the insect appears to have been near the peak of abundance. This insect was present in Prince Edward Island but was less injurious than in 1937.

Garden crops, and more particularly flowering plants, were seriously damaged in New Brunswick, Quebec and Ontario by the feeding of the tarnished plant bug, *Lygus pratensis* L., which was extremely abundant in many sections. Dahlias, asters, gladioli and many other flowers were injured. At Algonquin, Ontario and in Ste. Clothilde, Que. celery growing in muck soil was heavily infested. This insect appears to have been more abundant than for a number of years. In New Brunswick the four-lined plant bug, *Poecilocapsus lineatus* Fab., was injurious to such crops as tomatoes, potatoes, currants and ornamental flowers and shrubs.

The squash bug, *Anasa tristis* DeGeer, was more than usually abundant in parts of Ontario in 1938. A severe outbreak occurred in Prince Edward county, Ontario, where squash raised for canning purposes were severely injured. The pest was widespread also west of Toronto, attacking different cruciferous crops.

Among miscellaneous insects attacking flowering plants, several species were more abundant than usual. The gladiolus thrips *Taeniothrips simplex* Mor., was present in destructive numbers in different parts of Ontario and Saskatchewan. In the western provinces buds and blossoms of wild and cultivated roses were severely injured by the feeding of the rose curculio, *Rhynchites bicolor* Fab. A widespread outbreak of the green rose chafer, *Dichelonyx backi* Kby, occurred in northern Saskatchewan where roses and plums suffered from the attack of the insects. In the Ottawa district and in New Brunswick lacebugs, of unknown species, seriously injured both perennial and annual asters, the attack being fairly

general throughout the district. Miridae, Pentatomidae, Cercopidae and Cicadellidae in general were unusually abundant in New Brunswick.

A widespread outbreak of the Colorado potato beetle, *Leptinotarsa decemlineata* Say, was reported from many points throughout Canada in 1938. The insect was unusually abundant in every province, although in British Columbia is still confined to a small area in the south and east. In Alberta it has practically disappeared from the Edmonton area, and in Saskatchewan, extends as far north as general agriculture. Many unsprayed fields in various parts of the country were a total loss although, fortunately growers generally have now become fully educated to the importance of the pest and take the necessary steps to hold it in check.

After a year of scarcity in 1937, the striped cucumber beetle, *Diabrotica vittata* Fab., appeared in quite considerable numbers in New Brunswick during 1938. The beetle was also a pest of importance in Nova Scotia, Manitoba and Saskatchewan where it appeared as a pest for the first time. Cucumbers, squash and melons were readily attacked and serious damage resulted in many districts. In Saskatchewan, east central portions of the province, chiefly within the parkland areas, were most heavily infested, but the beetles also occurred on the open prairie.

Primarily a pest on the prairies, the beet webworm, *Loxostege sticticalis* Linn., was unusually abundant in Manitoba, Saskatchewan and Alberta. For the first time on record injury caused by the feeding of this insect was reported in British Columbia, the outbreak occurring in the East Kootenays. At all points garden crops were attacked, beets, carrots, lettuce, onions, corn, potatoes, mangels, etc., being in many cases totally destroyed. In the irrigated sections of Alberta spraying of sugar beets was carried out to save the crop from caterpillars. In northern Saskatchewan the insects fed to a considerable extent on alfalfa bloom, reducing the yield of seed quite materially.

Late sweet corn and ensilage corn suffered from the attack of the corn ear worm, *Heliothis obsoleta* Fab., in different sections of Eastern and Western Canada. This insect was fairly abundant in Nova Scotia, although its distribution was somewhat variable. In New Brunswick injury was confined, to a very large extent, to the southern portion of the province where ensilage corn suffered mostly. The corn ear worm was relatively scarce in Ontario, although some injury to late sweet corn was noted in Kent and Essex counties. In the West, the insect appears to have been quite widely distributed over Manitoba and Saskatchewan, in some districts as high as 60 per cent of the sweet corn being infested.

The imported cabbage worm, *Pieris rapae* L. was abundant in most sections of Eastern Canada, but appears to have been less numerous than usual in the Prairie Provinces. Injury in the East was more marked during the late summer and autumn than earlier in the season, untreated crops being severely damaged. In eastern Canada, the zebra caterpillar, *Ceramica picta* Harr. is on the increase, the caterpillars being abundant on turnips, cabbage, peas and other garden crops in parts of Nova Scotia, New Brunswick and Quebec.

A severe outbreak of the tobacco worm, *Protoparce quinquemaculata* Haw. occurred on tomatoes in Hastings, Prince Edward and Northumberland counties, Ontario. Many fields were totally destroyed. The caterpillars were so numerous as to quickly defoliate the vines, leaving the fruit unprotected on the ground where it was quickly scorched by the sun. Losses in these counties were heavy. The insect was unusually abundant in most

sections of Ontario this year, causing serious injury to tobacco, also, in the western end of the province.

During 1938 in general there was an increase in the population of the European corn borer, *Pyrausta nubilalis* Hbn. in most counties of Ontario lying west of Toronto, with the exception of Kent and Essex, where clean-up measures were rigidly enforced and most carefully carried out. In these two counties there was a very considerable reduction. East of Toronto there was little, if any, increase and in some sections an actual decrease in numbers was noted. In Quebec a serious outbreak of the corn borer occurred on the Island of Montreal but apart from this the insect was of little economic importance in the province.

Sunflowers growing in Manitoba and Saskatchewan were subjected to the attack of the sunflower leaf beetle, *Zygogramma exclamationis* Fab., during the past summer. In one case potatoes were attacked and the insects were noticed feeding in certain instances on the false ragweed.

In the early summer an infestation of the European earwig, *Forficula auricularia* Linn., was discovered at Ayton, a small village in Grey county, Ontario. Subsequent investigation and scouting revealed the fact that the insect was firmly established, not only in the village itself, but also in many of the farms in the district. Due to the relatively wide distribution of the pest, eradication will be difficult. This is the first record of the European earwig in Ontario.

Due to favourable weather conditions, chiefly temperature, which prevailed during the growing season of 1937, a considerable increase and spread of the pea moth, *Laspeyresia nigricana* Steph., occurred last summer on the Gaspe coast, Quebec. This was noticed not so much in the older established areas throughout Bonaventure county, but in Gaspe county where up to now the insect has been relatively scarce. Considerable injury took place in sections along the coast which heretofore had reported no damage.

Yields of clover seed in western Ontario were much reduced in 1938, due to the attack of the clover seed midget, *Dasyneura leguminicola* Lint.

The pea aphid, *Illinoia pisi* Kalt., was of slight importance only, both in Ontario and Quebec. In the latter province, light infestations were noted in peas growing in the vicinity of St. Hyacinthe, Aubrey, Howick, Ormstown and at different points Rimouski county.

Middlesex county, Ontario, was again the scene of a light outbreak of the potato scab gnat, *Pnyxia scabiei* Hopk., potatoes growing in the vicinity of Caradoc being infested in certain cases.

Boring caterpillars of different species have been reported from several provinces in Eastern Canada. Moths of the potato stem borer, *Hydroecia micacea* Esp., were captured in large numbers in light traps operated in the Annapolis Valley, Nova Scotia. In New Brunswick, the same species was abundant in potato, tomato and corn crops growing in Madawaska county. The stalk borer, *Papaipema nebris nitela* Guen., was reported as attacking corn, tomatoes and miscellaneous flowering plants at different points in Ontario and the celery stalk worm, *Nomophila noctuella* Schiff. was present in injurious numbers in Essex county, damaging tobacco seedlings. The hop vine borer, *Gortyna immanis* Gn. severely infested the second year hops in the Fournier district of Ontario.

The spinach carrion beetle *Silpha bituberosa* Lec. occurred in abundance in at least two different sugar beet-growing districts in Alberta this season. Some early beets were destroyed by the larvae.

In Saskatchewan, the pepper grass beetle, *Galeruca externa* Say, occurred at St. Walburg, Onion Lake, Tatsfield and Scott.

Cruciferous plants in Saskatchewan and Alberta were seriously injured by the red turnip beetle, *Entomoscelis adonidis* Pallas. At Battleford, Sask., turnips were singled out for attack and severe losses occurred as a result.

Several species of chinch bugs were reported from different points in Canada during 1938. The hairy chinch bug, *Blissus hirtus* Mont., seriously injured a newly seeded lawn at Sackville, N.B., and what is probably this species also was reported from P.E.I.

In Manitoba and Saskatchewan the western chinch bug, *Blissus occiduus* Barber, was reported from widely separated points, feeding on wheat, barley, old brome grass, willow grass and pastures .At Brooks, Alberta, the false chinch bug, *Nysius ericae* Schill, was abundant and caused severe injury to apple tree seedlings.

The wheat stem maggot, *Meromyza americana* Fitch, occurred in about normal numbers in the Red river valley, Manitoba, and caused slight losses to grain fields located in the park belt of Saskatchewan.

Flea beetles, in general, were less important than was the case in 1937. The potato flea beetle, *Epitrix cucumeris* Harris, was present in small numbers in most potato fields visited throughout the Maritime Provinces and Quebec, but caused little loss. In Ontario this species was more abundant than usual and in addition to infesting potatoes was common in fields of tobacco and tomatoes where feeding was readily noticeable. The pale striped flea beetle, *Systena taeniata blanda* Melsh., was reported in outbreak numbers in a field of beans growing in Harwick township, Ontario, but little commercial damage seems to have resulted. Market gardens in southern Manitoba, particularly around Winnipeg and Brandon, were severely injured by the feeding of the garden flea beetle, *Phyllotreta lewisi* Crotch. Cabbages and radishes suffered most from the attack of

The presence of the Hessian fly, *Phytophaga destructor* Say, was reported from different points in Manitoba, Saskatchewan and Alberta. In no instance was the insect found in sufficient numbers to cause any appreciable crop loss.
these insects. The horse-radish flea beetle, *Phyllotreta armoraciae* Koch., was reported in a small patch of horse-radish growing in the Brandon district.

A pest which has gradually increased in importance in Alberta since 1934; namely Say's grain bug, *Chlorochroa sayi* Stal., was present this year in sufficient numbers to cause serious losses to wheat growing in the Turin and Chin-Wrentham districts. Due to the attack of this insect, both the yield and grade of the grain was seriously reduced. Say's grain bug was reported in scattered localities in Saskatchewan in 1937, but in 1938 it was present practically everywhere in the area south of the South Saskatchewan river and west of a line through Elbow, Regina and Estevan. Isolated specimens occurred as far north as Saskatoon .No really serious infestations were found in the province, the heaviest ones being at Maple Creek and between Dollard and Eastend.

White grub injury to crops occurred in Digby County, Nova Scotia, southern and central Quebec and the Niagara and Oshawa districts in Ontario. Although pastures and meadows suffered the most spectacular injury, forest tree seedlings, raspberries, strawberries, corn, potatoes, grain crops and garden seedlings also were attacked. June beetle flights at Fredericton, New Brunswick, and heavy flights over most of Ontario during 1938 indicated serious damage from second-year grubs at these points during 1939.

Carefully planned surveys of potato fields carried out in the Maritime Provinces and Quebec, in districts specializing in the production of certified seed potatoes, indicated that aphids were less abundant than in 1937. The potato aphid, *Macrosiphum solanifolii* Ashm., was the species most frequently encountered, with the green peach aphid, *Myzus persicae* Sulz., ranking next in importance. In connection with the latter insect it is interesting to note that not a single specimen was taken in parts of Quebec province where the survey was carried out. *Aphis abbreviata* Patch and *Myzus pseudosolani* Theo. were present in many of the fields visited but were not so abundant or as important as the first two mentioned species.

In southwestern Ontario the corn aphid, *Aphis maidis* Fitch, was present in numbers greatly above normal.

The Chrysomelid, *Phyllobrotica decorata,* caused some injury to spinach and weeds at St. Walburg. This is the second instance of damage by this insect reported in Saskatchewan, the first being to potatoes at Big River in 1927.

Mexican bean beetles, *Epilachna varivestis* Muls., were reported as occurring in small numbers near Blenheim, Grimsby and St. Catharines, Ontario. It was taken also in Japanese beetle traps at Port Dalhousie and Beamsville.

Numerous complaints of injury to stored beans by the bean weevil, *Mylabris obtectus* Say, were received from Ontario and Quebec. The pea weevil, *M. pisorum* L, has become more abundant since the establishment of a dried pea industry in the North Okanagan valley of British Columbia.

False wireworms, larvae of *Eleodes* sp., were plentiful throughout the prairie area of Saskatchewan and especially in the southwest. Adults were particularly conspicuous during the late summer. The small *Blapstinus* was probably even more abundant in the same area, adults being present in considerable numbers this spring wherever observed. *Blapstinus* larvae were present in far greater numbers than ever before encountered at Saskatoon. No records of damage to grain were received, but it seems safe to assume that some injury resulted, at least in the southwest.

FRUIT INSECTS

There was a further increase in infestation of the codling moth, *Carpocapsa pomonella* L., in the Annapolis valley, Nova Scotia, but serious outbreaks occurred only in the Berwick and Waterville districts, where certain varieties in some apple orchards showed from 40 to 60 per cent injured fruit. The species also appeared in increased numbers in several orchards in the Abbotsford and St. Hilaire districts of Quebec. In Ontario, data indicate that the codling moth population was lower in the Niagara district than for several years, and that the second brood was a small one. However, although generally in the province the species was not a serious pest in well-cared-for orchards, severe injury occurred in many apple

orchards in the Niagara-Burlington district and in Essex county. This may have been due to poor timing of sprays resulting from unusual seasonal conditions, and to heavy precipitation in July and August impairing the protective coat of spray. In the Okanagan valley, British Columbia, the codling moth is now considered to be probably the most serious pest in apple orchards. The 1938 season was particularly favourable to the insect.

There was a definite increase of infestation of the apple maggot, *Rhagoletis pomonella* Walsh, in apple-growing sections of Eastern Canada, in 1938, especially in neglected or poorly sprayed orchards. Where the infestation occurred in commercial orchards it was generally light.

Fruit aphids were not of outstanding importance in the Dominion in 1938. The rosy apple aphid, *Anuraphis roseus* Baker, occurred in outbreak numbers in many orchards of the Annapolis valley, Nova Scotia, but timely treatment prevented a general outbreak. The species was not important in other regions. The apple aphid, *Aphis pomi* DeG., was quite abundant in some orchards of the Annapolis valley, in June, but disappeared during July, probably owing to excessive rains. Local outbreaks of this species occurred in south-western Ontario, but generally the insect was of no importance. The woolly apple aphid, *Eriosoma lanigerum* Hausm., was again prevalent in the Annapolis valley, and showed a further increase in numbers. No outbreaks occurred this season in British Columbia, where the parasite, *Aphelinus mali,* is numerous, and appears to be a decisive control factor.

The infestation of the gray-banded leaf roller, *Eulia mariana* Fern., appeared slightly heavier in the Annapolis valley, Nova Scotia, than in past years. Apparently it is spreading into many orchards where it was not troublesome before. Where special control measures have been used it has been greatly reduced in numbers. The fruit tree leaf roller *Cacoecia argyrospila* Wlk., was responsible for much injury in several orchards around Bowmanville, Ontario. A marked increase in the population of this species was also noticed in a large orchard in Norfolk county, but elsewhere the infestation was negligible to light. In British Columbia there has been no serious damage from this pest, although it appeared in some numbers in the Okanagan Centre district.

The eye-spotted budmoth, *Spilonota ocellana D.* & S., was troublesome in orchards in central and eastern Kings county, Nova Scotia, and there was a slight increase in some orchards in the western end of the Annapolis valley. Most orchards, however, showed a slight decrease. In Ontario, the budmoth was noticeable in a few orchards near Simcoe, and was fairly common in orchards here and there over the province.

In the Annapolis valley, Nova Scotia, the fall webworm, *Hyphantria cunea* Drury, the red-humped caterpillar, *Schizura concinna* S. & A., and the yellow-necked caterpillar, *Datana ministra* Drury, were more abundant than for several years, and tussock moths were moderately numerous. In the extreme western end of the valley the white-marked tussock moth, *Hemerocampa leucostigma* S. & A., in many places almost completely defoliated neglected apple trees. The spring canker worm, *Paleacrita vernata* Peck., caused heavy defoliation of fruit and shade trees in the South Shore area in Queens and Lunenburg counties.

In southern Ontario, the plum curculio, *Conotrachelus nenuphar* Hbst., was more abundant than usual on peaches, and in some orchards was responsible for a considerable amount of wormy fruit. Injuries caused by curculios feeding in late summer and fall were more prevalent on

apples than for several years. Local damage by this species was reported in Manitoba. In some parts of Abbotsford, Rougemont and St. Hilarie districts, Quebec, the apple curculio, *Tachypterellus quadrigibbus* Say, caused serious damage to apples.

The round-headed apple tree borer, *Saperda candida* Fab., was very injurious in Missisquoi county, Quebec, and also in several orchards in the Hemmingford section. In Ontario, near Kingston, an unusually heavy infestation was observed in a 50-acre orchard, in which almost every tree had one or more borers.

The buffalo tree hopper, *Ceresa bubalus* Fab., was responsible for serious injury to young trees in many fruit-growing districts in Ontario.

The pale apple leafhopper, *Typhlocyba pomaria* McA., was numerous in many orchards of the Annapolis valley, Nova Scotia, where it increased considerably over 1937. Outbreaks also occurred in many orchards in fruit-growing districts of Ontario. It was abundant in late autumn in a number of orchards of the Okanagan valley, British Columbia.

The mullein leaf bug, *Campylomma verbasci* Meyer, was prevalent throughout the Annapolis valley, Nova Scotia, where it caused extensive damage to apples, especially in Kings and Hants counties. Fruit of susceptible varieties was practically ruined in some orchards.

No outbreaks of the apple and thorn skeletonizer, *Hemerophila pariana* Clerck, were reported in Eastern Canada during 1938.

The tarnished plant bug, *Lygus pratensis* L., was prevalent in vegetable and flower gardens in Nova Scotia, but was not reported as being injurious in orchards to any extent. In Ontario, it caused less injury than usual to fruit nursery stock. In 1937, this species was reported as probably responsible for a type of injury to peach fruit known as "cat-facing". Observations in 1938 indicated that the injury was actually caused by *L. caryae* Kngt., which migrated from nearby black walnuts. At Penticton, British Columbia, *L. pratensis* L., L. *elisus* VanD., and *L. hesperius* Kngt., severely damaged pear and peach fruit in a young orchard containing a heavy growth of alfalfa.

An unusual occurrence in orchards in the Niagara district, Ontario, was the widespread development of the green soldier bug, *Acrosternum hilare* Say, in sufficient numbers to cause serious injury to pear and peach fruits.

A marked increase in abundance of the oyster shell scale, *Lepidosaphes ulmi* L., was reported in Nova Scotia Orchards, particularly in parts of King's county. The species was also troublesome in British Columbia. There appeared to be a reduction of the San Jose scale, *Aspidiotus perniciosus* Comst., in southern Ontario. This was noted even in unsprayed orchards, and much less scale was reported on fruit than in 1937. In the Okanagan valley, British Columbia, the scale is spreading to some extent. The European fruit scale, *A. ostraeformis* Curt., is widespread in the latter region particularly in the Kelowna district.

The European red mite, *Paratetranychus pilosus* C. & F., was not particularly numerous in the Annapolis valley, Nova Scotia, early in the season, but developed extensively in July and August, in spite of continued wet weather. The infestation developed too late in the season to cause very much injury, but many winter eggs were deposited. In southern Ontario, the species was more abundant on, and injurious to, plum and apple trees, than it has been for some time. A few reports of mite injury

to peach trees were also received. In British Columbia, injury by this mite was serious in the south Okanagan. The pear leaf blister mite, *Eriophyes pyri* Pgst., was again common in some localities in Nova Scotia, and was particularly troublesome on nursery stock. It was not an important pest in Ontario in 1938, but was prevalent in a number of orchards in the Okanagan valley, British Columbia.

Injury to fruit by the oriental fruit moth, *Grapholitha molesta* Busck., was at a low level in both the Niagara district and south-western Ontario. In the Niagara peninsula the average twig infestations by first and second brood larvae were lower than in 1937, being 0.94 and 2.5 per cent in 1938 compared with 2.1 and 3.4 per cent in 1937. Counts in orchards and information from canning factories indicated a smaller third brood than in 1937, in spite of apparently favourable weather conditions. Replies to a questionnaire sent to canning factories in the Niagara district showed that in most peach orchards there was less than 1 per cent wormy fruit. In south-western Ontario first generation injury was considerably heavier than in 1937, averaging 8.5 per cent, but the average twig injury by the combined first and second broods dropped from 22.4 per cent in 1937, to 17.1 per cent in 1938. There was also a pronounced reduction in the third brood, with a corresponding reduction of wormy fruit. Parasites, notably *Macrocentrus ancylivorus* Roh., were reported largely responsible for the general low level of the infestation. Other important species were *Cremastus minor* and *Glypta rufiscutellaris* Cress.

The peach tree borer, *Synanthedon exitiosa* Say, was more injurious than usual to nursery stock, in the Niagara district, Ontario, but apparently was not exceptionally abundant in peach orchards.

Although in well-sprayed vineyards in the Niagara District, Ontario, the leafhoppers, *Erythroneura comes* Say and *E. tricincta* Fitch, caused no appreciable injury, the marked increase in population in unsprayed and poorly sprayed properties, recorded in 1937, continued in 1938 and resulted in severe damage to foliage and fruit.

FOREST AND SHADE TREE INSECTS

A few new locality records of the European spruce sawfly, *Diprion polytomum* Htg., were obtained in Prince Edward Island and Nova Scotia in 1938, and there was some evidence of a slight increase in numbers in Cumberland county, N.S. The infestation continues very light in these two provinces. In northern New Brunswick and Quebec the species was somewhat less numerous than previously, owing to an unusually high percentage of diapause. The trees were in about the same condition as in 1937. In central and southern New Brunswick, however, active larvae were more numerous than last year and a number of new heavy infestations appeared. The total area estimated as heavily infested in Quebec and New Brunswick is now about 12,000 square miles. Cruising on the Cascapedia river in the Gaspe peninsula, Que., indicated that the trees have continued to die at about the same rate as during the previous three years. About 70 per cent of the total volume of the white spruce was found to be dead. In western Quebec and Ontario, the spruce sawfly was generally present in the area surrounding lake Temiskaming, and in the country north and east of it, but there was an apparent decrease as compared with 1937.

The yellow-headed spruce sawfly, *Pikonema alaskensis* Roh., (-*Pachynematus ochreatus* Harr.), was again abundant in New Brunswick, Quebec, Ontario and the Prairie Provinces, and caused severe defoliation of planted spruce and of trees growing in clearings.

The spruce budworm, *Cacoecia fumiferana* Clem., was increasingly destructive on jack pine in parts of Manitoba and north-western Ontario, during 1938. Secondary beetles, particularly *Ips* and *Monochamus,* added to the general destruction of the pine in severely infested localities. In the Hawk Lake area, it appears that the mortality may reach 50 per cent. In southern Manitoba the percentage will be somewhat less. The budworm infestation now extends across the southern half of Manitoba, east to Port Arthur and south to the United States border. The greatest activity for 1938 developed in the vicinity of Dryden and Ignace, Ont., and in the Port Arthur region. South of Dryden, an area of not less than 10,000 acres was very severely attacked. In the Sandilands Reserve, in southern Manitoba, parasitism reached 79 per cent. Parisitism, particularly by *Ephialtes conquisitor* Say, apparently is keeping pace with the spread of the budworm, and in the Port Arthur region, varied from 20 to 25 per cent. The budworm also appeared in northern Manitoba and Saskatchewan, but in lesser intensity. In the Riding and Duck Mountains, it is common but not sufficiently numerous to cause serious injury.

The spruce budworm, *Cacoecia fumiferana* Clem., also caused severe defoliation in the Mississagi Forest Reserve, Ontario, and larvae were found on balsam fir east and west of this area. An increase in the numbers of the black-headed budworm, *Peronea variana* Fern., particularly near Thessalon, Ontario, was observed in the infested district. Three outbreaks of the spruce budworm have been reported from British Columbia and Alberta; at Barkerville, and on the North Thompson river, B.C., and at Fortress Lake, Jasper National Park, Alta. The Barkerville infestation, in which the budworm has a two-year cycle, has been sporadically active for a number of years. The Thompson river area, in the vicinity of Grizzly lake was examined in 1938, and the balsam reproduction beneath mature spruce and balsam was found to be most seriously affected.

The black-headed budworm, *Peronea variana* Fern., was generally present throughout the Maritime Provinces on fir and spruce, but nowhere numerous enough to do important damage. It occurred in small numbers on white spruce in Riding Mountains National Park, and at The Pas, Manitoba, and also in Britsh Columbia, but caused no noticeable injury.

The spruce mite, *Paratetranychus ununguis* Jac., increased in population over 1937 throughout the greater portion of the plains area of the Prairie Provinces. Indications are that it will be even more prevalent in 1939.

The red-headed pine sawfly, *Neodiprion lecontei* Fitch, was less numerous in western Quebec and northern Ontario than in 1937. The infestations at Mattawa, Ont., and at Kipawa, Que., had practically disappeared, and no larvae could be found in the plantations near Nairn and Thessalon, Ont. Small roadside plantings on the North Bay-Huntsville highway were moderately infested. Disease appeared prevalent among the larvae. The heavy infestation of this species in the Petawawa Forest Reserve has practically disappeared, although the insect was not uncommon in a plantation of red pine at Renfrew, Ont. In Quebec, the sawfly is still abundant at Lachute, St. Boniface, and Lanoraie, but in reduced numbers.

The sawfly, *Neodiprion abietis* Harr, caused moderate to severe defoliation of balsam along the highway from Blind River, Ont., to the end of the Trans-Canada Highway at Mica Bay. Damage was most severe near the lakes, but extended for some distance up the valleys of the Goulais and Mississagi rivers. A moderate infestation of this species was reported from Masson, Que.

A sawfly resembling *Neodiprion abietis* Harr., feeding on jack pine and red pine was much more abundant in north-western Ontario during 1938 than previously recorded. Its distribution appears to be the same as that of the spruce budworm on pine, although its role as a destructive insect in this area apparently is a minor one. In some instances, however, red pines were almost completely stripped of their foliage. The identity of this species has not yet been established. It appears to be widely distributed and occurs commonly in western Quebec.

The European pine shoot moth, *Rhyacionia buoliana* Schiff., has pen etrated into the heart of the reforested areas in Norfolk county, Ontario. It is also abundant in the Niagara Falls and St. Catharines areas. In May, this insect was discovered on several pines (*Pinus contorta* var.) in a garden in Vancouver, British Columbia. Subsequent scouting showed the moth to be present over an area of at least five city blocks, indicating that it has probably been there for several years. Providing no widespread infestation is discovered, complete eradication will be attempted in 1939.

The jack pine scale, *Toumeyella* sp., is a serious pest in the Sandilands Forest Reserve, Manitoba. The year 1937 was apparently very favourable for it and several new centres of infestation appeared. Not much increase in area was recorded in 1938, although the infestation extends over about 10,000 acres. The scale was found to attack jack pine, Scotch pine and red pine, in the order named. In severely infested areas, the tree mortality is about 15 per cent. Indications are that the scale is not increasing, and natural control, as high as 90-95 per cent was recorded in some areas.

The larch sawfly, *Pristiphora erichsonii* Htg., was again numerous throughout most of southern New Brunswick and some parts of the north-eastern end of Nova Scotia. Some stands were completely defoliated, but the majority suffered from 25 to 75 per cent defoliation. The species *Bessa selecta* was again the common parasite in certain localities. No trees have yet been observed to die from the present outbreak. In Ontario, the sawfly was observed everywhere from Mattawa to Sault Ste. Marie and from Huntsville to Smoky Falls. In the Noranda area about 75 per cent of the larvae were parasitized by *Bessa selecta,* but in other areas parasitism was lower. Throughout northwestern Ontario and Manitoba, the sawfly was particularly active in 1938. While no serious outbreaks were recorded, it was discovered in small patches at intervals from Schreiber, Ontario, westward to the Spruce Woods Forest Reserve in Manitoba. The most severe infestation was found in the latter area, where defoliation was most pronounced and cocoons wre abundant in the moss in moist areas. In British Columbia, the larch sawfly was reported in outbreak numbers from St. Mary's Lake near Kimberley and on the head waters of Goat river near Kitchener. No westward extension beyond Slocan lake has been reported.

The eastern spruce bark beetle, *Dendroctonus piceaperda* Hopk., increased somewhat in the interior of the Gaspe peninsula, Quebec, but, in general, has been acting more as a secondary than a primary insect, attacking trees injured by the European spruce sawfly, in association with secondary bark beetles. Nearly half of the dying trees had some *Dendroctonus in them.* A few new attacks were also discovered near Lake Metis, Que.

Bark beetles, particularly *Ips.* have been active throughout the budworm-infested areas in Manitoba and north-western Ontario, and consti-

tute a problem in areas of severe defoliation. No serious outbreak in healthy timber has yet occurred but the beetles are a considerable factor in hastening the death of already weakened trees.

The mountain pine beetle, *Dendroctonus monticolae* Hopk., is still active over a considerable area of lodgepole pine in the vicinity of McLeod Meadow, in Kootenay National Park, British Columbia. Associated with it is *Ips interpunctus* Eich., which in certain areas, is causing the main tree mortality. *Ips* is also attacking a number of trees near the waterton Lakes townsite in Waterton Lakes National Park.

The douglas fir bark beetle, *Dendroctonus pseudotsugae* Hopk., is active in standing timber at Comox lake on Vancouver Island.

The weevil, *Hylobius radicis* Buch., was found doing severe damage to a plantation of Scotch pine, near St. Martins, N.B. Half the trees were dead or dying and the remainder appeared likely to succumb. A nearby plantation of red pine was also attacked.

The spruce weevil, *Pissodes sitchensis* Hopk., has caused damage to spruce terminals in many parts of British Columbia, notably in the plantations at Green Timbers Forest Nursery, New Westminster, at Courtenay, and near Victoria. It attacks sitka, Norway, and Engelmann spruce.

Severe defoliation by the Douglas fir tussock moth, *Hemerocampa pseudotsugata* McD., has occurred in the vicinity of farms at Armstrong, Larkin, and Vernon in the Okanagan valley, British Columbia. There are also two small outbreak areas in the open forest near Armstrong and Lavington.

Specimens received show the hemlock looper, *Ellopia fiscellaria* Gn., to be widely distributed over the southern interior of British Columbia. Extensive damage was reported in the Parry Sound and Muskoka districts of Ontario, apparently the only records of injury by this species in Eastern Canada, in 1938.

The balsam woolly aphid, *Adelges piceae* Ratz., increased somewhat in the Maritime Provinces, although it is still less numerous than in 1933. A few trees are being killed at scattered points throughout southern New Brunswick, and some small spots of heavy infestation were noted in Nova Scotia.

The mountain ash sawfly, *Pristiphora geniculata* Htg., was more numerous than last year and caused severe to complete defoliation of a considerable number of mountain ash in southern New Brunswick. Some of these were planted, others were growing naturally in the forest. A steady increase has been noted in Quebec since the discovery of the species in 1934. It has spread into Ontario and occurs commonly at Ottawa.

The infestation of the forest tent caterpillar, *Malacosoma disstria* Hbn., continues to be severe along the Ottawa valley, very heavy defoliation being reported from Ville Marie to Temiskaming, and from Mattawa to Deux Rivieres. The outbreak centering around North Bay and Sudbury appears to be on the decline, and a decrease is also reported from north-western Ontario. Localized outbreaks have occurred in the Prairie Provinces and the Eastern Townships of Quebec. No injury has been reported from the Maritime Provinces.

The fall cankerworm, *Alsophila pometaria* Harris, caused severe defoliation in and around Liverpool, Nova Scotia. It was more numerous this year in Fredericton, New Brunswick. In the woodlands between Fred-

ericton and Jemseg, N.B., the majority of the elms were severely or completely defoliated. In Saskatchewan and Manitoba, this insect was again abundant on Manitoba maple and elm. The most extensive injury in Saskatchewan occurred in the area lying between the North and South Saskatchewan rivers, east of the meridan of longitude through Wilkie. A large area south of the South Saskatchewan river, through Mawer to Moose Jaw was also involved. A number of localized outbreaks occurred in the Indian Head district. In Manitoba, rather heavy infestations were centred around Brandon, Virden, Portage la Prairie, and Lyleton. Many plantations were completely defoliated and are now in a very weakened condition.

The bronze birch borer, *Agrilus anxius* Gory, was still more numerous this year in New Brunswick. The majority of trees in most of the mature yellow birch stands showed evidence of attack. Some stands on steep slopes had been almost destroyed, but the mortality on good sites was mostly less than 50 per cent. The majority of the trees, however, showed injury to the tops. The species was also active and caused considerable damage in north-western Ontario. Serious injury to birch occurred in Prince Albert National Park, Saskatchewan.

The beech scale, *Cryptococcus fagi* Bsp., was again numerous in southern New Brunswick, and some heavy infestations were reported as far north as Fredericton and Douglas township in York county. A considerable number of trees died in 1938, particularly in the lower parts of the St. John river valley.

The infestation of the satin moth, *Stilpnotia salicis* L., was lighter in some areas of New Brunswick, in 1938, but new or heavier infestations occurred in others. Some heavy infestations still persist in and around Moncton but, in general, complete defoliation apparently does not take place over more than one or two years. In some localities, after one year of stripping, the insect has become comparatively scarce. The imported parasites, *Apanteles solitarius* and *Compsilura concinnata* appear to be important in reducing the period of severe infestation at many points. New outbreaks were found in several places in Westmorland and Albert counties, New Brunswick, and in Cumberland, Pictou and Inverness counties, Nova Scotia.

Numerous walnut trees were defoliated over a wide area in southwestern Ontario by the walnut caterpillar, *Datana integerrima* G. & R. A heavy outbreak also occurred in 1937.

The spiny maple worm, *Anisota rubicunda* Fab., has been very abundant in Ontario and Quebec, particularly in eastern Ontario and along the St. Lawrence valley.

The boxelder leaf roller, *Gracilaria negundella* Chamb., was in widespread outbreak form throughout the major portion of the Prairie Provinces in 1938. In many areas, one hundred per cent of the leaves of Manitoba maple (boxelder) were mined or curled. In many instances, trees were totally defoliated. The outbreak was the heaviest yet recorded. This insect was also widespread in northern Alberta. About 75 per cent of the foliage was destroyed around Edmonton, where the insect had not previously been observed. Adults were very numerous in late summer.

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Ontario Department of Agriculture

Seventieth Annual Report

of the

Entomological Society

of Ontario

1939

PRINTED BY ORDER OF

HON. P. M. DEWAN, Minister of Agriculture

ONTARIO

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1939

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FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31st, 1939

Receipts		*Expenditures*	
Cash on Hand	368.37	Printing the Canadian Entomologist	1,128.00
Dues	312.93	Salaries	250.00
Subscriptions	467.44	Postage & Express	66.04
Advertisements	428.15	Annual Meeting (1938)	56.47
Government Grant	350.00	Reprints	20.00
Back Numbers	173.00	Bank Exchange	14.89
Miscellaneous	53.00	Miscellaneous	68.27
Bank Interest	11.40	Stenographic Assistance	20.00
		Balance on hand in Bank	540.62
	$2,164.29		$2,164.29

Respectfully submitted

REG. H. OZBURN,
Secretary-Treasurer.

Audited and found correct

L. CAESAR
G. G. DUSTAN
Auditors.

ENTOMOLOGICAL SOCIETY OF ONTARIO

REPORT OF THE COUNCIL, 1938-1939

The Seventy-fifth Anniversary of the Society was celebrated at the Ontario Agricultural College, Guelph, on November 23rd to 26th, 1938, under the chairmanship of Dr. Arthur Gibson, Dominion Entomologist.

Some thirty-six Societies and Institutions in Canada and the United States were represented by delegates. Letters of congratulations and good wishes were received from some sixty other Societies, Institutions and individuals unable to be represented or present at the meetings.

The banquet on Thursday evening tendered by the Ontario Agricultural College was an outstanding success. Dr. Gibson, acting as chairman, announced the delegates present and the Societies or Institutions represented and read a list of the Societies and Institutions from whom letters of congratulations had been received. Dr. Christie, President of the College, in extending a welcome to the gathering offered official and personal congratulations. Mr. W. A. Reek, Deputy Minister of Agriculture for Ontario, brought greetings and congratulations from the Honourable P. M. Dewan, Minister of Agriculture for Ontario, and tendered the well wishes of the Department. Professor A. W. Baker then gave an account of the early history of the Society illustrated by some slides. Dr. W. E. Saunders, Dr. John Dearness, and Dr. Arthur Gibson were then introduced as the members of longest standing present at the Anniversary Meetings. Dr. Dearness and Dr. Saunders reminisced on the early days of the society, the latter presenting the Society with a bound manuscript on "Insects of Staple Crops" prepared by his father, Dr. W. Saunders, one of the Society's founders.

On Friday evening an enjoyable smoker was held in the Faculty Lounge. The enjoyment of the evening was greatly enhanced by the papers of Mr. F. Morris on "Woodland Lures" and Mr. C. E. Petch on "Etymology and Entomology".

All sessions of the meetings were very well attended, about sixty papers being presented and discussed. Of outstanding interest during the regular sessions were the coloured films of insect life presented by Professor A. L. Melander of the College of the City of New York. During the last session, Dr. Saunders and Dr. Dearness were given honorary memberships. (For details of the Seventy-fifth Anniversary Meetings see Volume 71, No. 1, of the Canadian Entomologist, 1939.)

The Council is happy to report that the Index to the Annual Reports of the Entomological Society of Ontario from 1900 to 1937 has been published through the courtesy of the Department of Agriculture, Province of Ontario. This index, which should prove a useful addition to entomological literature, will be mailed to the members of the Society and to the subscribers to the Canadian Entomologist with the Sixty-Ninth Annual Report of the Society.

The Canadian Entomologist, the monthly journal of the Society, completed its Seventieth Volume in December, 1938. This volume contained some sixty-seven original articles and research notes, nine book notices and reviews, and fourteen news items. These pages contained twenty-two plates and fourteen text figures and were contributed to by fifty-three authors from Nova Scotia, New Brunswick, Quebec, Ontario, Saskatchewan, Alberta and British Columbia and fifteen of the United States.

RECORD OF PAPERS PRESENTED AT THE 76th ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, HELD IN QUEBEC CITY, NOVEMBER 2-4th, 1939

President's address,—"The development of Economic Entomology in Quebec," Dr. Georges Maheux, Plant Protection Service, Quebec.

"Entomology and the War"—Dr. Arthur Gibson, Division of Entomology, Ottawa, Ont.

"Some Foreign Plant Quarantine Problems"—Dr. E. R. Sasscer, Bureau of Entomology and Plant Quarantine, Washington, D.C.

"Some Activities of the Plant Protection Division"—Leonard S. McLaine, Plant Protection Division, Ottawa, Ont.

"Fumigation Methods Employed in the United States to Prevent the Spread of the Japanese Beetle"—H. A. U. Monro, Fumigation and Inspection Station, Montreal, P.Q.

"Organization of the Quebec Plant Protection Service with Special Reference to the Section of Entomology"—Dr. George Maheux, Plant Protection Service, Quebec, P.Q.

"The Insect Collection of the Quebec Department of Agriculture"—Jos. I. Beaulne, Plant Protection Service, Quebec, P.Q.

"Insect Quarantines Actually in Force in Quebec"—Pellegrin Lagloire, Plant Protection Service, Quebec, P.Q.

"The Use of Centralization in New Entomological Publications (Gen.)"—Noel M. Comeau, Provincial Museum, Quebec, P.Q.

"The Sweeping Movement of the Junior Naturalists"—Dr. Georges Prefontaine, University of Montreal, Montreal, P.Q.

"Project of a Provancher Museum at Cap Rouge"—Noel Comeau, Provincial Museum, Quebec, P.Q.

"Methods and Materials of a New Technique for Using Pomace Flies in Biological Tests with Contact Insecticides"—Harold T. Stultz, Dominion Entomological Laboratory, Annapolis Royal, N.S.

"Lepidoptera with Positive Phototropism Collected at Granby Field Laboratory"—Paul Eugene Mercier.

"Notes on the Distribution of Mosquitos in Canada"—C. R. Twinn, Division of Entomology, Ottawa, Ont.

"A Contribution to the study of the Trichoptera of the Laurentide Provincial Park (Montmorency)"—Father O. Fournier, University of Montreal, Montreal, P.Q.

"The Forest Insect Survey in 1939"—Dr. A. W. A. Brown, Division of Entomology, Ottawa, Ont.

"The Classification of Forest Insect Injury"—A. R. Gobeil, Entomological Service, Department of Lands and Forests, Quebec, P.Q.

"The Satin Moth in Quebec"—Dr. Geo. Maheux, Plant Protection Service, Quebec, P.Q.

"*Agrilus anxius* and its Association with the Dying of Birch in New Brunswick"—R. E. Balch, Dominion Entomological Laboratory, Fredericton, N.B.

"Some Possibilities in the Control of the Pine Sawyer Beetle by Chemical Methods"—Peter Morley, Dominion Entomological Laboratory, Laniel P.Q.

"The Two Species of *Semiothisa* on Tamarack"—W. C. McGuffin, Division of Entomology, Ottawa, Ont.

"Insects Collected in the Laurentide Provincial Park during the Summers 1938 and 1939"—Gustave Chagnon and Father O. Fournier, University of Montreal, Montreal, P.Q.

"Biological Control of Insect Pests in Canada with Special Reference to the Spruce sawfly *Diprion polytomum* Hartig."—A. B. Baird, Dominion Parasite Laboratory, Belleville Ont.

"The Technique of Randomizing Field Work"—Dr. Geoffrey Beall, Dominion Entomological Laboratory, Chatham, Ont.

"The Frequence of a Partial Second Generation of *Carpocapsa pomonella* L. in Quebec"—Andre A. Beaulieu, Dominion Entomological Laboratory, Hemmingford, P.Q.

"The Emergence of Adults of *Carpocapsa pomonella* L. as Observed by Means of Bait Traps During the Last Three Years"—Andre A. Beaulieu, Dominion Entomological Laboratory, Hemmingford, P.Q.

"Results of Experiments on the Codling Moth"—Andre A. Beaulieu, Plant Protection Service, Quebec ,P.Q.

"Observations on the Rose Stem Girdler, *Agrilus communis rubicola*"—W. G. Garlick, Dominion Entomological Laboratory, Vineland Station, Ont.

..Studies on the Plum Nursery Mite, *Phyllocoptes fockeui*"—Wm. L. Putnam, Dominion Entomological Laboratory, Vineland Station, Ont.

"Life-History of the Plum Leaf Hopper, *Macropsis trimaculata*"—T. Armstrong, Dominion Entomological Laboratory, Vineland Station, Ont.

"Biological Control of Greenhouse Insect Pests"—J. H. McLeod, Dominion Parasite Laboratory, Belleville, Ont.

'The Parasites of the Pea Moth, *Laspeyresia nigricana* Steph."—Geo. Wishart, Dominion Parasite Laboratory, Belleville, Ont.

"The Potato Aphid Surveys in Eastern Canada"—R. P. Gorham, Dominion Entomological Laboratory, Fredericton, N.B.

"Studies on the Biology and Noxiousness of the Strawberry Weevil on the Island of Orleans"—Paul Morisset, Plant Protection Service, Quebec, P.Q.

"Preliminary Notes on the Life-History of the Tobacco Worm, *Phlegethontius quinquemaculata* Haw. in Ontario"—Dr. G. M. Stirrett and A. A. Wood, Dominion Entomological Laboratory, Chatham, Ont.

"The Present Status of the Hop Vine Borer, *Gortyna immanis* Gus. in the Province of Quebec"—Rene Mougeot, Plant Protection Service, Quebec, P.Q.

"Experiments on White Grub Control by Cultural Methods"—Geo. Maheux and Geo. Gauthier, Plant Protection Service, Quebec, P.Q.

"Hypopharyngial Characters and Their Use in the Determination of Lepidopterous Larvae"—H. A. Gilbert, Division of Entomology, Ottawa, Ont.

"A Co-operative Exchange of Grasshopper Parasites between Argentina and Canada with Notes on Parasitism of Native Grasshoppers"—C. W. Smith, Dominion Parasite Laboratory, Belleville, Ont.

"The Effect of Hail Storms on Grasshoppers"—Geo. J. Spencer, University of British Columbia, Vancouver, B.C.

"Three Years Experience on the Biology and Control of the European Corn Borer, *Pyrausta nubilalis* Hbn..—Geo. Gauthier, Plant Protection Service, Quebec, P.Q.

"Notes on Corn Borer Resistance in Hybrid Corn with a Brief Statement on the Corn Borer Situation in Ontario in 1939"—R. W. Thompson, Ontario Agricultural College, Guelph, Ont.

"Notes on the Control of *Lygus pratensis* L. on Celery"—J. B. Maltais, Dominion Entomological Laboratory, Hemmingford, P.Q.

"A Test of Sodium Fluoride Bait in the Control of the European Earwig in Ontario" —A. G. McNally, Ontario Agricultural College, Guelph, Ont.

"Influence of the Factors of Light and Heat on the Emergence of *Sceliphron cementarium* and *Chalybion caeruleum* Hymen."—Noel M. Comeau, Provincial Museum, Quebec, P.Q.

THE DEVELOPMENT OF ECONOMIC ENTOMOLOGY IN QUEBEC

Presidential address: 76th Annual Meeting

By GEORGE MAHEUX

Director, Quebec Plant Protection Service, Quebec

It affords me very great pleasure indeed to welcome you all, members of the Entomological Society of Ontario, distinguished visitors and guests, who have travelled long distances to attend the first meeting in Quebec of what is, in fact, the Canadian Association of Entomologists. Quebec greets you, Quebec is glad to see you!

Any Canadian citizen is naturally at home in any part of Canada, but this is especially true of old Quebec, the cradle of Canadian civilization. For their part, Quebec entomologists have every reason to rejoice as they have long awaited the pleasure of this occasion. I wish to thank, very heartily, the members of the Council who so spontaneously accepted the

invitation I tendered them, last year at Guelph, to come to Quebec for this meeting of the Society. In so doing, we feel you have conferred upon us a great favor and, at the same time, given encouragement to a small group of young workers.

In the name of the Minister of Agriculture, whose invitation I conveyed to you last fall, but who, unfortunately, is unable to attend this meeting, I welcome all of you to Quebec. The attendance is larger than we expected and we are especially favored in having with us some of the prominent men in the entomological field in Canada and United States. Most of you are familiar with large institutions or connected with highly developed entomological laboratories, divisions, etc.

We have nothing to show you that can really compare with what you know or what you have seen elsewhere. Yet, we have no excuse to offer for our present situation; we might even be proud of the little we have accomplished if we take into account the difficulties, misunderstandings, and prejudices we had to fight against to reach the point where we stand to-day. In fact, entomology in Quebec is a rather young undertaking and it might perhaps interest you to have a sort of bird's eye view of the development of economic entomology in French Canada.

The Provancher Period (1850-1892)

In every country, entomology stands as a younger science than botany. Although there seems to be no good reason for the slower development of entomology and this apparent discrimination in the field of natural sciences, it is a fact that everywhere applied entomology came chronologically after botany. The first naturalist in French Canada, Michel Sarrazin (1658-1734) was a botanist. Some other amateurs followed in his steps and in the earlier part of the 19th century many plant collections were made around teaching institutions. No sign of entomology, under printed form, can be retraced earlier than 1857.

In the field of natural sciences, we must confess that prominent men in the French part of Canada were very rare. Notwithstanding the abundance of our natural resources; in spite of the historical fact that Quebec has lived and could survive, over a period of nearly three centuries, only through the exploitation of lands and forests; in spite of this immense field opened to the application of the various natural sciences: this long period has left only one name capable of holding an important place among the naturalists, and this is the name of l'abbé Leon Provancher. Provancher dominates the whole period of 1850 to 1892. He was undoubtedly a born naturalist whose spirit of observation and natural curiosity led to the study of the environment. His merit cannot be over-estimated; he had to train himself all alone and at a time when only literature and oratory were in favour with French Candians. To choose such a new walk of life and thus singularize himself required greater courage than we can imagine.

From the begnning of the 19th Century a definite movement towards the study of nature had been launched in England, France, Germany and other European countries; the United States followed immediately for, as early as 1805, W. D. Peck was appointed professor of Natural History at Harvard College; 1812 marked the foundation of the Academy of Natural Sciences at Philadelphia, and 1830 of a similar institution at Boston.

As early as 1830, natural history was accepted as a special course in High Schools by our English speaking fellow-countrymen showing they had a keener sense of realities than the educators in Lower Canada. Thus, these men were teaching their partners in Canada a great lesson. In Quebec, past generations could boast of their great fondness for the beauty of the humanities, but your own ancestors practiced, and long before us, a more complete humanism and a less artificial one. since they studied not only printed texts but also Nature's book. Due credit must be given these pioneers who exercised a beneficial influence upon Provancher. Undoubtedly encouraged by what was done in Ontario and New England, Provancher immediately set to work. The first manifestation of his interest in entomology is a small publication which appeared in 1857. It is a pamphlet entitled "Essai sur les maladies et les insectes du blé" by *Emilien Dupont,* of St. Joachim. The author's identity was later discovered; Provancher used the name of his gardener for a "nom de plume". This publication seems to be the first one, dealing with economic entomology, ever published by a French Canadian.

Until 1862, Provancher's main interest remained with the study of plants. In that year appeared his "Flore Canadienne" and this book stood for nearly 75 years as the only work on systematic botany in Canada. From 1862 to 1868 Provancher, leaving to others the field of Botany, became more and more interested in entomology. Until the end of his life he patiently gathered the material for his main work modestly entitled "Petite faune entomologique du Canada", which at the time of his death, in 1892, covered over 3000 pages. Although Provancher is better known as a systematist, he also wrote a few pages on injurious insects. Besides the essay already mentioned, he wrote in 1862 a booklet on orcharding (Le Verger Canadien) and later a similar work on the vegetable garden. A new edition of these two publications appeared in one volume in 1874. The revised text contains in all 18 pages on insects and their control, and this marks, in chronological order, the second manifestation of economic entomology in French Canadian literature.

A pioneer naturalist with broad knowledge and vision, a prolific writer and a man of numerous initiatives, Provancher stands as the real founder of Natural History in Quebec, especially as our first and foremost entomologist. It belongs to the entomologists of to-day to preserve his memory in a lasting monument such as the transformation of his Cap-Rouge residence into a Provancher Museum.

As to the papers in the English language, special mention must be made of many articles published by William Cooper in The Canadian Naturalist and Geologist. Dr. Arthur Gibson, who is a keen student of the early entomological history in Canada, informs me that Cooper published, in 1858, a paper on "*Saperda candida* in districts surrounding Quebec"; that William Stuart M. d'Urban published, in 1857, "Notes on Insects injuring crops in the Vicinity of Montreal". There are probably other stray publications which have escaped the writer's attention, but no attempt to completeness is being made in this brief review.

THE TRANSITION PERIOD (1892-1914)

Following Provancher's death there seems to have been a short period of hesitation among Quebec entomologists. "Le Naturaliste Canadien" had disappeared with its founder and editor; it was revived in 1894 by Reverend Canon V. A. Huard, a close friend of the lamented abbé, who decided to continue the work of his master. During this period and judging from

the material printed in "Le Naturaliste Canadien", the trend of entomology slowly shifts from a pure science to its economic applications. Among that group of amateurs who were contributors to the "Naturaliste Canadien", the following deserve special mention: Germain Beaulieu and Gustave Chagnon, two very active collectors whose works on systematic entomology are familiar to most of you, were at that time taking entomology as a hobby. but later adopted this science as their main undertaking. Mr. Beaulieu spent a few years with the Entomological Branch in Ottawa, but unfortunately he was forced through eye sight trouble to return to the practice of law. Mr. Chagnon is still actively engaged in the field of entomology and he has published extensively during the last decade. He is now the dean of Quebec entomologists and we take this occasion to extend to him our best wishes and deep appreciation.

Going over the file of the "Naturalist" at the beginning of this century, the writer has come across the names of: abbe Elias Roy, Reverend Dr. Fyles, both of Levis; James Fletcher. Ottawa; abbé P. A. Begin, Sherbrooke; J. C. Chapais, W. H. Harrington, Jos. I. Beaulne, etc. James Fletcher, Canon Huard and J. C. Chapais are the only contributors writing on economic aspects. but the importance of insect control is becoming more and more evident as we reach the end of this period. An interesting detail may be mentioned here in passing. In one of the numbers of "Le Naturaliste" for the year 1901, there is an article signed by Félix d'Hérelle ("chimiste a Longueil") who is now universally known as the discoverer of the "bacteriophage", a theory which has found successful applications even in insect control.

Repeated outbreaks of various injurious insects prepared public opinion to become more deeply interested in entomology and compelled government officials to do something to check the pests. At that time Dr. Fletcher was slowly organizing the Entomological Branch at Ottawa. His influence was certainly felt in Quebec, thus preparing the ground for a provincial organization. He and his successor, Dr. Gordon Hewitt, had certainly something to do with the preparation of the Agricultural Instruction Act, for an item of the grant made to Quebec under this Act calls for work in "horticulture and entomology". Indirectly, this Act brought about the appointment of the first provincial entomologist in Quebec in 1914.

Other signs of progress during this period may also be pointed out as they have had an important bearing upon the development of economic entomology. First of all comes the foundation of Macdonald College in 1907, with a department of biology headed by the late professor Lochhead and the announcement of a regular course in entomology, very likely for the first time in Quebec. Then comes the Society for the Protection of Plants (1908) putting together the isolated workers in entomology and plant pathology, holding annual meetings and publishing an annual report. Their activities and writings had a great influence in agricultural circles. To sum up this period, we may say that entomology was preparing itself so as to serve the best interests of the nation, especially in agriculture and forestry.

When the fruit seemed to be ripe an important event took place that hastened the official recognition of entomology as a necessary branch of agricultural endeavour: a widespread grasshopper outbreak suddenly broke out in 1914, probably the worst menace that ever threatened Quebec agriculture; it was successfully controlled by the Entomological Branch in Ottawa and clearly proved the importance of insect control in agricultural welfare. Thus a new era was beginning.

THE ECONOMIC PERIOD (1914-1939)

The first provincial entomologist was appointed in 1914 and in the same year the Legislative Assembly passed the first Plant Protection Act. The late Dr. Gordon Hewitt was instrumental in the preparation and adoption of this Act. Thus the Department of Agriculture began to take an interest in plant protection at large end especially in entomology. The consequences of this official step have been beneficial and numerous; let us mention the teaching of entomology as a special course in Agricultural and Forestry Schools; the development of the Division of Entomology which is now part of the Plant Protection Service organized three years ago; the publication by the Department of Agriculture of a large series of bulletins and circulars for the benefit of the growers. In this same period appeared a few books such as Lochhead's "Economic Entomology", Beaulieu and Maheaux's "Les Insectes nuisibles du Quebec", "Les Melasidae du Canada" by Beaulieu, "Les Coléoptères du Quebec" (still in course of publication) by Gustave Chagnon, Daviault's "Faune entomologique des Bétulacés"; also numerous articles in agricultural and scientific periodicals.

Let us also mention the lists of insects of the Province published by the Society for the Protection of Plants and to which the following workers contributed: Beaulieu, Chagnon, Winn, Petch, Maltais, Walker.

For the sake of brevity and clearness, the main factors that have contributed to the development of economic entomology in Quebec during the last 25 years may be enumerated as follows, although not necessarily in order of importance:

1. *The Division of Entomology at Ottawa.*—I have already mentioned the role of Dr. Gordon Hewitt in the preparation of the first Plant Protection Act. Dr. Hewitt and Dr. Gibson have always been for us the best of advisers. Relations between the federal and provincial entomologists were always marked by the most beneficial co-operation. The co-operation of Dr. Swaine, Mr. de Gryse and their associates in the field of forest insects, led lately to the creation of a forest insect service, connected with the Department of Lands and Forests; co-operation has also been very evident in agricultural entomology with H. C. Crawford. L. S. McLaine, C. E. Petch and W. A. Ross, especially in connection with the control of foreign invaders, the control of outbreaks and investigations on some new or highly noxious species. I wish to take this opportunity to express the gratefulness of the Quebec entomologists to their friends in Ottawa. Their unceasing efforts to develop entomology under the Federal Government has been very helpful to the workers in the provincial domain. A close association of the two organizations is an absolute necessity and we hope this beneficial situation will improve and last.

2. *The Society for the Protection of Plants and Macdonald College.*—In grouping together all those concerned with the protection of plants this society, founded in 1908 by the staff of Macdonald College, has rendered great services to the cause of entomology. Through its annual meetings, the publication of its reports, and its lists of Quebec insects, a real spirit of collaboration has arisen and given stimulus to isolated workers. For our part, we can say that the contacts established at these meeings have been very beneficial in the pursuit of our work.

It is difficult to separate the influence of Macdonald College from that of the Society for the Protection of Plants. Yet, special mention must be made of that institution of learning because it was the first to have a special course in entomology and also on account of the influence that such men

as Professor Lochhead and Dr. Brittain have had upon the training of agriculturists and of well-equipped entomologists. Due credit must be given to these men who have rendered such services to Quebec agriculture. In the training of entomologists, two institutions have been responsible for the preparation of our graduates in agriculture or forestry who wished to specialize in entomology. To the name of Macdonald College, already mentioned, must be added the name of Cornell University where our young men have always found besides undisputable competency, a highly favorable scientific environment and lasting friendships.

3. *French Agricultural Schools.*—Although the teaching of entomology in the french agricultural schools has developed only in late years, they have always endeavoured to give their students a practical knowledge of injurious insects and their control. In this connection, I take special pleasure in mentioning the name of Father Leopold, a former president of the Society, who is in charge of the Department of Entomology at Oka, a department that has known, under his guidance, very important developments during the last 10 years.

4. *The Pomological Society.*—As early as 1912, perhaps even earlier, the Fruit Growers Society of Quebec adopted a plan of demonstration orchards for the purpose of testing the most efficient methods of fruit protection and also with the view of educating growers. From that moment dates the improvement of our fruit crop. At every one of the annual meetings many papers on fruit insects, spray materials and outfits, formed part of the programme. As a result of this educational work, a spray service was created under the auspices of the society in connection with the Department of Agriculture. At first, this spray service was limited to fruit growers but in later years it gradually spread to vegetable growers, potato growers, etc., until now it covers the whole province, which for that purpose has been divided into three sections: western, central, eastern. It is stated in the report of the Minister of Agriculture for 1938 that 44 spray notices on post cards were mailed to growers; 46,000 copies representing the total edition. If all classes of growers have benefited from this timely information, it is only fair to note that fruit growers have made more progress than all other groups. Proof of this is easily shown by the high quality of Quebec apples and also the flourishing situation of the orcharding industry in Quebec.

5. *Extension.*—Since 1914, all available means of extension have been resorted to educate farmers on plant protection. Just to give you a more precise idea of the variety and amount of propaganda handled by the Plant Protection Office, from 1916 up to 1938, allow me to mention some impressive figures:

Lectures to farmers	1,376
Field demonstrations	1,819
Inspections	63,683
Bulletins	20
Articles in periodicals	870
Radio talks	48
Circulars (mimeographed)	407

Judging from these statistics, it is obvious our growers absorbed a large share of our activities. Educational work had also to be carried on among the leading classes in order to enlist their sympathy and support for the realization of our plans.

Three other factors largely contributed to bring about a rapid change in the farmers' outlook. First, the control of outbreaks such as grasshoppers, army worms, corn borer, strawberry weevil, tent caterpillars, cutworms, etc., conducted with gratifying results in most instances. Secondly, insect quarantines which had a marvelous psychological effect upon the growers, deeply impressed them as to the importance of insect control and hastened their acceptation of efficient protection methods. Thirdly, Departmental help for the purchase of sprayers. This was a wise policy, as it induced producers to get better or more adequate equipment. Once the outfit was purchased it became very easy to induce most of the owners to make good use of them. In sections where farmers could not afford to buy sprayers, even with the grant, the Horticultural Service loaned traction or barrel sprayers which were used by a definite number of growers, many of which were bought co-operatively two or three years later. It is only just to state that this policy has been quite instrumental in rapidly spreading throughout the province the habit of regular sprays for pest control.

6. *Education of young farmers.*—We have always advocated the necessity for young farmers to get better acquainted with the elements of natural history if they were to become really interested in farming and also in plant protection. In 1922, we organized a competition in rural schools for pupils preparing small collections of insects and weeds. The competition went on for three years and there was quite a perceptible awakening of the younger generation of the rural districts in this regard.

With the aid of the district agronomists, these young naturalists were further encouraged by the Horticultural Service to cultivate a school garden and later induced to have their own plot of potatoes on the home farm for the protection of which the Department supplied small quantities of insecticides, fungicides and also small size hand sprayers or dusters.

The curiosity for natural sciences has been furthered in all parts of the province since 1932 due to the initiative of the "Société Canadienne d'Histoire Naturelle" which sponsored and gave life to the young naturalists clubs movement. There are now over 800 of these clubs in Quebec. The value of this type of education cannot be praised too much. It has been our privilege to measure its results with the activities of the young farmers clubs. Plant protection and insect control is not a surprise for these boys and girls; they adhere to it as to something normal and absolutely necessary. Their influence is spreading quite fast and now the great majority of our farming class has become insect conscious; routine is being thrown out and these farmers know that *production without protection is just a dream* that never comes true.

Competitions for insect collections are still maintained as part of the activities of the younger set in the farmers clubs.

7. *The Plant Protection Service.*—The activities of the new Plant Protection Service have been presented in the foregoing paragraphs; it is useless to repeat them here. Let me simply recall that 25 years have gone by since the appointment of the first provincial entomologist in Quebec.

In January of the current year (1939), an exhibition was put up in the various rooms of the Service to celebrate, in an entomological way at least, this anniversary. During the three days devoted to that exhibition nearly one thousand visitors had a chance to learn something about entomology, about our work, and also to see in retrospect the progress accomplished in the last quarter of a century.

What was our purpose? To stress before the leading class exactly the same facts we had tried to drive into farmers' minds:

1—Insects cost Quebec agriculture about $10,000,000. a year;
2—Insect control is an insurance for good crops;
3—Insect control is necessary for lower production costs;
4—Plant protection is an essential factor to put any farm on a sound economic basis;
5—Without plant protection methods no grower can successfully face competition.

Unceasingly preaching this protection gospel has finally brought the Plant Protection Service to a point where it can safely stand comparison with any of the other Services of the Department of Agriculture. Unknown or unexisting in 1914, the plant protection service has been raised from a one-man affair to where it now employs a staff of 36 men, with ten men devoting all their time to entomology.

Though very slow at the beginning, progress has been more rapid than we ever dreamed. even to the extent that, with but few exceptions, plant protection extension work is now done entirely by the district agronomists. Thus, entomologists may devote more of their energy to check insect outbreaks, to give growers technical guidance, and to solve other problems of vital importance to agriculture. Last summer we had five field stations in operation, where investigations were conducted on the biology and control of our worst insect enemies.

Under the able direction of Mr. Georges Gauthier, chief of the Entomological Section, 18 men have been working all summer at field stations, while Mr. Pellerin Lagloire and his inspectors took care of regulatory work and extension. At the head office in Quebec, we are building up a provincial collection; which we want to be quite representative of the insect fauna of the province. Our main laboratory is now in a position to render growers and others all desired services. A permanent station is also maintained in Montreal.

Looking now towards the future, we might say that our present organization is just about one tenth (in *importance, personnel, budget* and *efficiency*) of what it should be to adequately insure the defense of Quebec crops. Some people who are not entomologists might be "scandalized" by what they would term such a "bold" statement. If such people have this impression may I ask them: "If 10% of the crop value is the average annual loss due to insects, can agriculture be prosperous, can farmers have a decent standard of living without efficient insect control?" In all quietness I await the answer!

Canada, Quebec, Ontario and all other provinces, may rely upon the members of this Society in such a trying period. Entomologists are ready to fully do their share for national welfare and their efforts will be limited only by the means put at their disposal.

ENTOMOLOGY AND THE WAR

By ARTHUR GIBSON

Dominion Entomologist, Ottawa

During the Great War, the Dominion Entomological Service adopted a slogan, "Crop Protection Means Crop Production." In the present serious world crisis it is equally important that every effort be made by the

farmer, the fruit grower and all others who grow crops to realize the importance of protecting grain, fruit, vegetables, and other commodities from damage by insect pests. Cooperation in fighting insects is most essential in any effort to produce more and better crops. In times of war particularly, all who are concerned with the growing of crops, or the handling of crops already harvested, should realize the enormous losses which may result from the ravages of destructive insects.

In a message to the farmers of Canada urging increased crop production, on September 1, 1914, by the late Honourable Martin Burrell, then federal Minister of Agriculture, the following appeared; "It is difficult for us to realize what will be the effect on food production, through the withdrawal of several million men from all the great agricultural countries of Europe. These men cease to be producers, they become consumers;—worse still they become destroyers of food."

In a further message to the farmers of Canada in December 1915, Mr. Burrell expressed his own and the government's deep appreciation of the fine response made, the production results surpassing expectations. In January, 1917, the Minister stated:—"Amid the varying phases of this titanic conflict, the fact stands out more clearly than ever, that agriculture is of supreme importance."

Since the Great War all branches of science have made important advances. In an editorial in Nature entitled, "The Voice of Science," September 9, 1939, the following appears: "For the moment, the interests of pure science is an intellectual pursuit and discipline must remain in abeyance. The energies, the abilities, and the knowledge of each and every individual with scientific training must be directed without remission to the service of the allied cause."

In England at the present time, as a matter of urgency, all possible steps are being taken to increase the production of foodstuffs. "The aim is to obtain for next year's harvest, an increase of 1½ million acres in the tillage area in England and Wales, compared with the acreage in June last."

In September, 1939, on the recommendation of Honourable Mr. Gardiner, Minister of Agriculture, there was set up by Order-in-council, an Agricultural Supplies Committee. The duties of this committee will be to mobilize the Canadian agricultural industry in order to facilitate the maximum export of agricultural supplies to Great Britain and her Allies, and to ensure that the agricultural resources of the Dominion will be utilized to the best advantage. To do this, provision is being made for constructive direction of agricultural production, as well as the conservation of agricultural products.

Following the establishment of the agricultural Supplies Committee, a conference between Ministers, Deputy Ministers, and other officials of the Provincial and Federal Departments of Agriculture was held in Ottawa on September 27 and 28. At this conference the fullest cooperation of the Provinces with the Committee in any effort to promote the production of essential food products was pledged. One of the results of the conference so far as we, as entomologists are concerned, will be the setting up of Provincial committees. The members of these committees will meet to discuss and afterwards recommend, not only uniform remedial measures for controlling insects, but also the development of further co-operation

out of which all activities may be so co-ordinated as to assist in the bringing about of the best results in any crop production programme which will be urged upon farmers and others in the various Provinces of Canada.

In the grim struggle which faces Canada and the Empire today, the entomologist has a very pressing responsibility, not only in assisting production by methods of crop protection, so far as insect enemies are concerned, but also in the matter of the conservation of food supplies.

Since the Great War of 1914-1918, entomological research has made important advances. In Canada, both Federal and Provincial entomologists have added to our knowledge facts of undoubted value, specific and general,—facts which have been taken to the field, the orchard, the forest and the garden, resulting in cheaper and improved methods of controlling insect pests—facts, too, which have saved large sums of money in protecting products kept in store from the ravages of these small creatures. In a crisis such as is facing the world today, there must of necessity be a cessation or at least a slowing up for the present of many projects concerning which much further research is necessary; this so that our time and energies may be directed towards aiding the production of such crops in Canada, as England may urge be specially produced.

There is no doubt that during recent years particularly, the public generally have realized that an adequate supply of food, both vegetable and animal, would have been largely impossible without the knowledge gained from research work by entomologists, plant pathologists, and other scientific workers. Sufficient control data is now available for most of our important insect pests. In any campaigns looking to a greater production of crops in Canada during this new great war, the entomologist surely is in a position to render important aid.

In Canada, the new regulations under the Pest Control Products Act, will go into effect on January 1, 1940. Under these regulations, no insecticide will be allowed to be sold unless it is approved by the Department. Provision is made for guarantees of biological effectiveness as apart from chemical analysis. Growers of crops in Canada will thus be sure of securing insecticides of undoubted value. A special committee of the Department known as the Pesticide Supply Committee is being set up. Under the direction of the Agricultural Supplies Committee, the duties of the Pesticide Supply Committee shall be:—

1. To promote the efficient use of materials for the control of pests of field and garden crops, livestock and poultry, in support of a greater production programme.

2. To ensure sufficient supply of products needed for controlling pests affecting Canadian agriculture and industry.

3. To encourage the efficient manufacture and distribution of insecticides, fungicides and other pesticides required for safeguarding Canadian agriculture.

4. To take steps to prevent the export of materials used for controlling pests, which would endanger Canadian supply.

During the present emergency, the Canadian Insect Pest Survey, as directed by the Federal Division of Entomology, should render a particularly useful service. With the assistance of our own and Provincial reporters, prompt advice it is expected, will be received at Ottawa of any insect

outbreak of importance occurring in any of the Provinces of Canada. This information, in turn, will be distributed in districts where it should do most good. In this way prompt advice will be available which should result in the saving of much crop.

In closing, Mr. Chairman, I feel certain that during the continuance of the war in which Canada is now engaged, the members of the Entomological Society of Ontario—one of the oldest entomological societies in North America—will gladly do everything in their power to add in the important work of protecting much needed crops from insect enemies. For our people at home and those who serve in our armies, there must be a continuous supply of good wholesome food. As has been stated previously, insects can be as effective as submarines in destroying food supplies. Like submarines they are insidious in their operations. They must be sought out and destroyed.

THE PROVANCHER MUSEUM

By NOEL M. COMEAU

Zoologist, Quebec Provincial Museum

Some say: "See Naples and die!" Could we not say: "See Quebec and live for ever to remember its charms." In its immediate surroundings, just a few miles above, in an enchanted dale streaked by a little quiet river, in the midst of bushes and trees of all kind, lies a peaceful and neat, but yet historical village.

Those familiar with the above district have no doubt already recognized in this very brief description the well known village of Cap Rouge. The little stylish church, with its shining steeple, well guarded by a group of typical houses brilliantly coloured like a handful of precious stones thrown into a casket of greenness, is a very familiar sight to all Quebecers.

The red tile cape where the little Cap Rouge River meets the royal St. Lawrence is a sacred spot to the historians, for, there lie the ruins of a fort built by Jacques Cartier in 1541 and 1542; but what made Cap Rouge famous to scientists from Vancouver to Halifax, from New York to Los Angeles and from Texas to Labrador, is the courage, the arduous studies and gigantic works of a nature-loving genius; I have named l'Abbé Leon Provancher.

Who could deny that the man who has pointed out and paved with his science the way to the younger generation of naturalists, was not a genius? Provancher, apart from being a priest of great knowledge who stands as a prop to the catholic faith in Quebec, stands also as a pioneer as well as a master in botany, entomology, malacology and other fields of Natural History. By his numerous discoveries and well developed works in Natural History he has enlarged the horizons and even opened new trails to nature lovers; he has impressed and promoted in the soul of his fellow-countrymen the great desire to know and understand the unnumbered mysteries with which God has endowed nature.

Is not Provancher the founder of the Naturaliste Canadien, the oldest and still existing French Canadian review strictly devoted to science, of which each word is an appeal to the studies of our fauna.? With practically no financial support, Provancher published his Naturaliste Canadien from 1869 until his death in 1892, being at the same time sole proprietor and chief editor, and nearly always the only writer of a scientific monthly review of 32 pages, and on some occasions of 48 pages, each one bearing a secret detached from nature.

This unique type of scientist in North American History lived in a modest wooden house resting in a "coquet" little orchard, comparable in beauty to a miniature botanical garden. The house is a two story one with a so-called semi-french-type roof. The front of the house painted in black and white, and according to those who have known Provancher, always offering an open door inside of which the heartiest welcome awaited you. At the right of the entrance hall you could see the laboratory, a room crowded with drawers of unassorted insects and mollusks, shelves covered with stuffed birds, pots and jars of snakes and frogs, walls decorated with stuffed fishes, piles of botanical specimens, books scattered all over, manuscripts sheets piled up here and there under a certain denomination, and on the table, an oil lamp with a peculiar shade, the inseparable companion of a home-made microscope.

But to enter this room of science you would have had to be either a scientist, a collaborator or a very close and intimate friend. Should you not have been any of these, a no less hearty welcome awaited you in the room at the left, dining and living-room combined, where comfortable old style armchairs invited you for rest. There even the most ignorant person would feel a touch of nature; familiar birds would be on shelves in every corner.

At the end of the hall, on the right, and connecting with the laboratory was the museum, (a big word for a room of 8 x 10, but how much more interesting than many large buildings bearing that name). Museum and laboratory were provided with glass closed bay-windows that Provancher used as breeding cages for insects. Shelves with pots of flowers created the necessary atmosphere, little oval sliding panels allowed the insects to come in for light trapping, a convenient ventilation was also arranged, in a word as he states himself; "Every thing is ordered so as to give the insect the feeling of being free and that no one is watching, observing or taking notes of its doings."

The room used as a Museum was quite simple, no seats, table or furniture whatever except one of those heirlooms called a "sideboard", four medium-size cabinets with drawers filled up with insects numbered and labeled, and in the right corner an old chest of drawers where Provancher kept his herbarium.

At the back of the house, on the left and opposite the museum room, the kitchen, in the center of the hall a two story stove and alongside a narrow stairway leads on to the second floor. Right on top at the right, Provancher had his private chapel, small but convenient, in front a door to his bed room. On the left of the stair two bed rooms, one for his niece who lived with him until his death and the other one in front of the house, over the laboratory was the guest room. I was told that Chanoine Huard of Quebec City, his intimate friend and disciple, to whom he had given all of his science works, was the one who used it the most often.

I have hereto tried to describe you in a few words the house where the father of taxonomic entomology in Canada lived his last twenty but most fruitful years; very unfortunately, this historical house is running into ruins. Bought some thirty years ago by a man named Beaupre, it has not been granted anything beyond an outside coat of green yellow paint in the year of its purchase. It was inhabited until last fall, but since that time used as a shelter for mice and rats. The inside partitions are still the same as Provancher left them in 1892, even the wall paper in the guest room has not been changed, as I was told by old Michel Blondeau, a close neighbour of 82 years of age and a great admirer of Provancher, who heartily offered his subscription drawn from his old-aged pension fund. This house you will see to-day.

Would not all the scientists of North America rejoice to hear that a committee of restoration has been set up to bring the name of Provancher into the great light again and have it known to all? This committee has chosen the name of "Le Comité du Musée Provancher" and has elected as President, Dr. Georges Maheux, whose qualities need not be cited here, his fame has already passed outside the borders of this province and country. Le Comité du Musée Provancher is formed of twelve members, and is honoured by such names as Frere Marie-Victorin, Director of the Montreal Botanical Garden, Omer Caron, assistant-director to Dr. Georges Maheux of the Provincial Dept. of Agriculture, J. Henri Paquet, assistant-director of the Quebec Provincial Museum, Charles Fremont, Superintendent of the Hunting and Fishing Dept., Gerald Coote, director of the Société Zoologique de Quebec, Abbé J. W. Laverdiere, geologist of Laval University, Dr. Edmour Perron, ex-president of l'Association canadienne-francaise pour l'Avancement des Sciences, L. Z. Rousseau, president of l'Association des Ingénieurs Forestiers and Robert Hunter, president of La Société Provancher d'Histoire Naturelle du Canada. Abbé V. Pouliot, parish priest of Cap Rouge acts as vice-president and Noel M. Comeau as secretary-treasurer.

The Comité du Musée Provancher intends to buy the house, restore and transform it into a museum where could be seen all of Provancher's furniture that is still to be found, and a lot of his personal goods which he had given away, as those who had kept them as precious souvenir have been very gracefully put at our disposal. Also can be seen all of his published works, scientific and others, his museum and laboratory equipment, his collections of entomology, zoology, ornithology and ichtyology, formed out when possible of the duplicates of his personal collections, also a complete copy of his herbarium, together with the original containers.

For this above purpose the committee, at the closing of the ACFAS Congress launched an official public subscription fund, the aim of which is to raise $4.000.00. This amount provides for all expenses prior to the opening of the Museum as well as a maintenance foundation. Personal subscriptions of $10.00 and $15.00 have already been received from admirers of Provancher, some scientific societies have voted and subscribed as much as $100.00 for their share apart from individual subscription from their members.

As secretary-treasurer of Le Comité du Musée Provancher I hereby make an appeal to the honourable members of the Ontario Entomological Society and anticipate the pleasureful duty of sending an official receipt to every member of this great society as well as to their friends. The treasure chest is now open and awaits the run of gold to fill it. It is important that it be filled before February next in order to purchase the house at the low option price and that by next spring the Provancher Museum can be opened to visitors.

Permit me as a closing to cite, with very minor change these words of our great Canadian poet, Wallace Havelock Robb:

"By Vancouver and beyond Bradore
"Provancher hear them cry.
"The birds of yonder shore
"Are wheeling in the sky,
"They would not disregard thy fame
"Nor cover up thy worthy name
"Nor thy great life deny.
"Shall men be the one only
"To forget you, O Provancher?

All subscriptions should be addressed to the secretary-treasurer of the Comité du Musée Provancher, Cap Rouge, Quebec, in order that an official receipt may be issued and name inscribed in the list of the founders of the Museum.

THE SWEEPING MOVEMENT OF THE JUNIOR NATURALISTS' CLUBS IN QUEBEC

By Georges Prefontaine

University of Montreal, Que.

A Junior Naturalists Club is a group of children, boys or girls, whose object is to train its members in the study, observation, and sympathetic comprehension of Nature in all its aspects. The end in view is therefore essentially educative. To develop the sense of observation of the child, to train his eyes to the contemplation of Nature, to expand his soul to the beauties and harmony of the surrounding world, to open his heart to sympathy and love toward all living beings, animals and plants, birds and flowers, beasts and forests is the noble task intended by these associations. The idea therefore is not to make "savants" out of these children, but simply to open to them the great book of Nature, so that they can easily read from it the words of life and marvels, and benefit by all its human value.

That this adaptation of the minds to nature does correspond to the instinctive curiosity of the child and to a profound desire of the educators, is shown by the rapidity with which these organizations have multiplied.

History and development.—The idea of the Junior Naturalist Clubs was proposed for the first time, in January 1931, by a member of the Congregation of the Holy Cross, Brother Adrien, to the members of the Canadian Society of Natural History that holds its meetings at the University of Montreal. This Society formed a committee to study the project which was adopted.

The first Club was founded at Longueuil College, near Montreal, in March 1931. One month later, there were twelve. After one year there were a hundred and fifteen; after three years, three hundred and fifty four. Now there are actually eight hundred and twenty-seven clubs with a total membership of about 25,000. They are to be found in all educational centers: in the large and prosperous institutions of big cities as well as in the most humble country schools, and the latter ones are the object of our particular attention; they are found in primary and high schools, in Colleges and Normal Schools. There are even juvenile clubs, and one of them, recently founded by a young lady scientist bears the name of l' "EVEIL" ("the awakening"), and it constitutes a veritable pedagogical experiment, for it is formed only by children of ages from three to seven.

The Junior Naturalist Clubs cover the whole Province of Quebec and are extending throughout the country in the French sections of the provinces of the Dominion. A few clubs are even operating in foreign countries, such as the United States, France, Egypt, India, etc.

Constitution.—The constitution of a Junior Naturalist Club is very simple. The club is administered by a board composed of a director or a lady director, a president, a vice-president, a secretary, and two councillors. The director or the lady director are named by the authorities of the school where the club is established.

The motto of the Clubs is the well known word of Christ to men: "Consider the lily in the field."

Each club bears a special name and is independent in so far as its own administration is concerned, but they are all affiliated with the Canadian Society of Natural History, whose headquarters are at the University of Montreal. We have decided to give this lien a tangible sign, which is an affiliation diploma. For the make-up of this diploma a contest was held with the condition that its text should be enclosed in an artistic design representing the Wild Yellow Lily.

Ways and Means of a J.N.C.—What are the ways and means through which the Club can function? They are many, and they vary, it is easily understood, according to local resources, and to circumstances of time and locality. The following is a list of the most important of these functions:

1. Regular meetings (once or twice a month) with "papers" read on the results of field trips, observations, and so forth, or short lectures on subjects dealing with conservation, natural life, etc.

2. Contests, (collections, drawings, field-trips, reports, etc.)

3. Space given in papers and periodicals, for reports, essays, and information service on Natural History.

4. Leaflets published at the rate of at least sixteen per year. Sixty-nine have been already distributed; which means 2 million copies. About 3,000 booklets and pamphlets bearing on educational ideas such as the protection of our Natural Resources are also yearly distributed.

5. Special lectures delivered throughout the province by the director of the movement. These lectures average 200 every year.

6. Exhibitions. Either *local* (every club has its own every year), or *regional* (ten or twelve every year) or *general*, held once every two or three years in cities such as Montreal, Quebec, etc. The next one will be held in Montreal in 1942.

7. External activities have been grafted onto the J.N.C. movement, such as petitions for bird sanctuaries, botanical or zoological gardens, the school of "The Awakening", and so forth.

Financial resources.—I should now like to draw attention to the financial administration of these associations. This is, as may be noted, a big organization with numerous activities. One will undoubtedly ask oneself what is the financial backing of the J.N.C.? During many years the Society of Natural History that patronizes the Clubs did not provide a regular income for them, no endowment, or any regular grant. Nevertheless it adopted and held to the following principle,—that the young members should never contribute a cent for anything whatsoever.

If the first work of the J.N.C. has been made possible, it is mostly due to the devotedness and material cooperation of the educational institutions who have enthusiastically accepted the idea. For certain expenses such as printing of the leaflets, travelling expenses of the lecturers, and so forth, the Society of Natural History did receive in the beginning, and once in a while later, the financial support of the Montreal School Board, of the Canadian Association for the Advancement of Science, (which is itself subsidized by the Quebec Provincial Secretary), and of a certain number of friends. For the latter category of supporters, there has been

established a method of cooperation through a $25.00 donation to the Society of Natural History, whereby the doner becomes a life-member of this Society, but at the same time the patron and protector of a specified club. So far, the Junior Naturalists Clubs have won to their cause fifty-seven patrons. Since 1936, the Government of Quebec has subsidized the Clubs for propaganda work and the maintenance of a permanent secretarial staff.

The Junior Naturalist Clubs will play a prominent role in general education, in the bettering of the public mind, in the solution of the grave problems concerning our natural resources, in the propagation of the principles of social hygiene, in the foundation and maintenance of National Parks, Botanical Gardens and Museums of Natural History. All elements of the population are thus directly interested in their success: families and governments, schools and universities, educators and pupils, business and professional men, financiers and labourers, and all inhabitants of cities and country. Should present resources fail them, I believe that the devotedness which has upheld the Clubs down to the present time would accomplish the miracle of upholding and promoting them again, and in spite of any difficulty.

GLANCE ON CENTRALIZATION OF NEW PUBLICATIONS IN ENTOMOLOGY

By Noel M. Comeau

Quebec Provincial Museum, Cap Rouge, Que.

Any one who has given himself to a practical way of studying Natural History knows the unnumbered difficulties he meets in the identification of his specimens. Unfortunately these difficulties, instead of becoming less as science goes on, are on the contrary, increasing in number at each step.

I believe for my part, although I may be the only one to do so, that entomology is the branch of science presenting the greatest difficulties to the beginner. This is true even for the more advanced entomologist, unless one happens to be a specialist in such or such a group and at the same time employed by a government or an university.

Who would not admit that the great factor of discouragement in learning Natural History is the too large number of publications and lack of funds for the beginner to secure them? Is there any member of this Society who has not encountered this embarrassment? Is there any one of us who has not experienced the tremendous amount of research, investigation and comparison that is necessary sometimes in the apparently simple identification of an insect. Even at the point which entomological science has now reached, complete monographs of each family are not all up to date, and it may be still a long while before we can count on them.

Are there any means of rendering research results more available and in this way hasten the time when these monographs might be more and more numerous. Let us suppose that this Society adopts a rule that all future communications on entomology should be published simultaneously in the "Canadian Entomologist" and in the "Naturaliste Canadien" in order to be official; each of these publications to accept such communication in either language, English or French, making it a duty to disregard as

official any new communication published elsewhere without being republished inside of six months in the two official scientific reviews mentioned. Those who desire or have the necessary means would not for this reason omit to secure any monograph or publication needed, but for the one, to whom money is scarce, and that is a general rule for the beginner, there is the possibility of learning and keeping oneself up-to-date for the very few dollars that it would cost for subscriptions to a limited number of official papers devoted to science.

I have no doubt the above suggestion would serve a good purpose, and I hope that this society will put the subject on its program for study. The plan, if found advisable, might be submitted to some American entomological societies who would probably also have a couple of official publications. It would thus be possible for a subscriber to 4 or 5 monthly entomological reviews to be immediately informed of any new discoveries in America. Under present arrangements many months may go by before new findings are known to the run-for-money beginner.

If I am well informed, the American Ornithologist's Union have adopted this way of proceeding and it seems that no paper is official unless publication in the AUK or the CONDOR has been made. Would not this plan be very useful in entomology where the needs and discoveries are ten times more numerous than in ornithology?

In closing, may I express the wish that the Ontario Entomological Society, as being the oldest and largest organization of entomology in Canada, give this plan its kind consideration and, if necessary, give the idea a fair trial for a few years.

Let us Government employees and University teachers who have large libraries at hand, think of the great number of younger or less fortunate entomology lovers, who will be the masters of tomorrow, for we, in this way could well serve science and country.

THE POTATO APHID SURVEY IN NEW BRUNSWICK AND ADJACENT PROVINCES

By R. P. Gorham

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In connection with the studies on the virus diseases of the potato begun at the Dominion Laboratory of Plant Pathology, Fredericton Experiment Station in 1933, there developed the need for information on the aphids present in the commercial potato fields of the province. The staff of the Fredericton Entomological Laboratory was asked to cooperate in obtaining this information and a beginning was made in June, 1934. In August of that year the cooperative assistance of the inspectors of certified seed potatoes of the Division of Botany in New Brunswick was first enlisted to secure samples of aphids from fields visited by them in the course of their work. These samples were forwarded to the Entomological Laboratory for examination and identification and greatly extended the scope of the survey beyond that which could have been accomplished by the entomologists alone. The work has been carried on cooperatively with the assistance from time to time as the surveys extended of the certified seed potato inspectors in the provinces of Prince Edward Island, Nova Scotia, New Brunswick and the eastern part of Quebec, latterly of the

Plant Protection Division, the plant pathologists of the Division of Botany and Plant Pathology, the provincial entomologists of Quebec and officers of the Division of Entomology. At first samples were taken from widely separated potato fields of all types in an effort to find the general distribution of the aphids. Later attention was confined largely to the commercial potato growing areas and in the last two years almost entirely to the fields being grown for certified seed production.

In 1934, 740 samples were collected from 203 farms in New Brunswick and two farms in the province of Prince Edward Island. In 1935, 1936 and 1937 the work was continued in New Brunswick with a few samples from Prince Edward Island. In 1938, the scope of the survey was extended to cover a larger portion of Prince Edward Island and portions of Nova Scotia and Quebec. A further extension was made in 1939. In that year 1512 samples were received from New Brunswick, 1145 from Prince Edward Island, 398 from Quebec and 374 from Nova Scotia. In the six-year period 5939 samples were received and reported upon. With improved methods for looking after the samples it was possible in 1939 to furnish a daily report to all collaborating officers including the field inspectors who made the collections.

One object of the survey each year was to locate districts where certain virus spreading species of aphids were abundant or absent and a second object to find the trend of population increase or decrease. In this connection maps were prepared at the close of each season's work. Four species of aphids were found to be common upon the potato plant. The relative abundance of these is shown in the total number of times they were recorded in 5939 samples taken in the years 1934 to 1939.

Macrosiphum solanifolii Ashmead	4597
Aphis abbreviata Patch	1525
Myzus persicae Sulzer	822
Myzus pseudosolani Theobold	289

Macrosiphum solanifolii Ashmead, is the most common aphid on potato plants in the four provinces. It appears on the plants in late June, becomes most abundant in late July and leaves the plants in late August. It is very subject to the attacks of predacious insects, parasitic insects and fungi. The population from year to year varies widely but the species is nearly always present in mid-season samples.

Aphis abbreviata Patch, is the second most common aphid but is not found in all districts. This has led to a study of the distribution of its winter host plant, the buckthorn, *Rhammus* sp. It is a small aphid which lives on the undersides of the lower leaves of the potato plant often under very moist conditions. It is subject to attack by fungi but is not often seen to be parasitized or attacked by predators unless there is none of the larger aphids present on the plant.

Myzus persicae Sulzer, the green peach aphid, appears on the plants during the second week of July in Nova Scotia, somewhat later in New Brunswick. Its reproduction is favoured by hot dry weather and it reaches maximum abundance in the second week of August. It feeds upon a variety of plants and after potato haulms die it can be found on weeds in potato fields, particularly weeds of the family Cruciferae. It is subject to attack under field conditions by parasites, predators and fungi. It fluctuates in abundance from year to year in the districts where it is found.

Myzus pseudosolani Theobold, is a warm weather insect and most abundant during the second week of August. Thus far its distribution has been found somewhat local in certain districts. It is very subject to parasites and fungi.

The economic value of the survey is both direct and indirect. The direct value is that it enables the field inspector who finds a field of seed stock aphid infested to obtain an immediate identification of the species present and if it is a virus spreading one to judge whether the potatoes from that field will be desirable seed stock the next year or not. The indirect value is that it shows which districts are habitually liable to infestation by virus spreading species of aphids and which are not, and hence where foundation seed stock can be grown to best advantage.

From the field survey of the aphid population have developed other lines of investigation having to do with the distribution of winter host plants, the environmental conditions best adapted for seed stock production, the rate of aphid reproduction, susceptibility of varieties to aphid transmission of virus diseases, resistance to low temperatures, etc.

PRELIMINARY NOTES ON THE LIFE-HISTORY AND BIOLOGY OF THE TOBACCO WORM. *PHLEGETHONTIUS QUINQUEMACULATA* HAW. IN ONTARIO

By GEO. M. STIRRETT AND A. A. WOOD

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So far as is known, no previous study under Ontario conditions has been made of the life-history of this important pest of the tobacco and tomato crops. Certainly no information has been published. It is because such information is necessary before adequate and intelligent control methods can be formulated that the following preliminary remarks and observations are given.

Weekly egg and larval counts on 100 unsprayed white mammoth tobacco plants were made at the Dominion Experimental Sub-station, Delhi, Ontario, in each of the two years, 1938 and 1939. Delhi is the centre of the flue-cured tobacco district of Ontario, located as it is in the so-called new belt of Ontario tobacco production. The plants were situated within a six-acre block in 1938 and within a 15-acre block of tobacco in 1939. The same plants were not selected for examination each time, but were selected at random within the small unsprayed block left for this purpose.

The results of the counts are shown in the following table and graph.

TABLE 1—SHOWING NUMBER OF EGGS AND LARVAE PER 100 PLANTS FOR SEASONS 1938 AND 1939, DELHI, ONTARIO

Date of Examination	No. eggs	No. larvae	Date of examination	No. eggs	No. larvae
June 23	0	0	June 28	4	0
30	0	0	July 7	24	32
July 8	5	0	14	50	65
15	26	6	19	41	117
21	20	43	27	4	94
25	12	52	Aug. 3	24	133
Aug. 11	0	25	10	16	77
22	0	10	18	2	69
28	0	2	24	1	74
			31	0	44
			Sept. 7	0	26
			15	0	11
			21	0	4
			28	0	2
			Oct. 8	0	1
			15	0	0

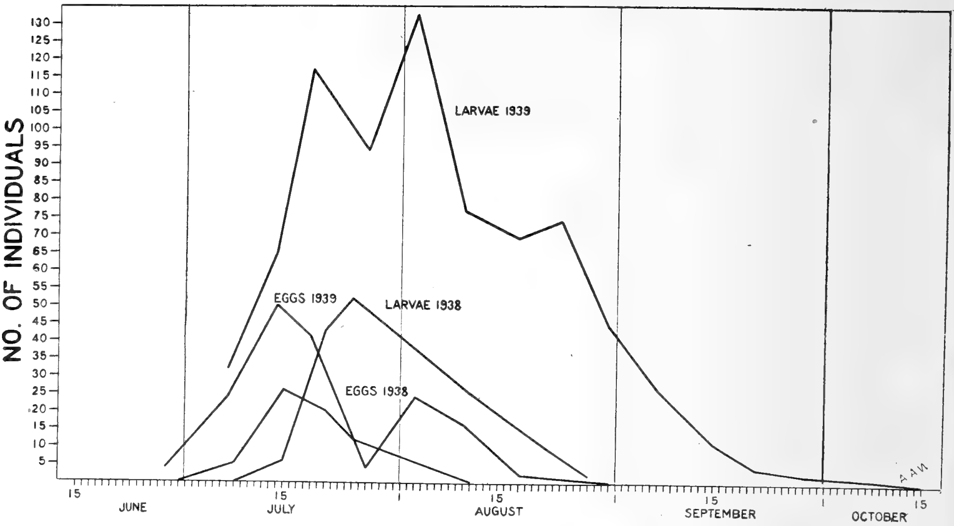

FIGURE 1

Fig. 1. Graphic presentation of the number of eggs and larvae found on 100 tobacco plants during the seasons of 1938 and 1939, Delhi, Ontario

The period of flight can be judged by the data on eggs. The pre-oviposition period is short, lasting from two to three days, according to Gilmore, 1939 (1). In both years, eggs were found in the field at Delhi on the same day that the first adults of the season were observed in flight.

There is a considerable variation as to the date at which moths, and consequently eggs and larvae, appear each year. Definite observations were not made previous to 1938, but the extent of variation may be judged by the date upon which the staff of the Dominion Experimental Sub-station at Delhi sprayed their tobacco for the control of this insect. These dates have been supplied by Mr. F. A. Stinson, officer-in-charge. They are as follows: 1935—August 3; 1936 - July 16; 1937 - July 12. The sprays were applied as soon as young worms were noticed on the plants. It will be seen from Table 1 and in Figure 1 that eggs were laid about sixteen days earlier in 1939 than they were in 1938 and consequently larvae became numerous and had to be poisoned earlier in 1939 than in 1938.

Not only does the date of commencement of flight and oviposition vary from year to year, but the duration also varies. It will be noticed that in 1938 the oviposition period was 18 days, while in 1939 it extended over a period of 44 days. Similarly, the length of time the larvae are present on the plants varies. In 1938, they were present for a period of about 45 days, while in 1939 they were present for about 94 days.

The records of egg deposition show that, at least, during the years under discussion the insect had a single generation in Ontario. Garman and Jarrett (2) record two generations in Kentucky, while Gilmore (1), 1938, records the same number for Tennessee and Kentucky.

There is a considerable variation as to the intensity of the infestation from year to year. It can be seen from Table 1 and from Figure 1, that the infestation in 1939 was much greater than that of 1938. The infestation of 1939 was, in the opinion of old growers, as great as any experienced. During the period of greatest egg deposition, the plants bore one egg to each 3.8

plants in 1938 and one egg to each two plants in 1939. At the height of larval abundance, there was one larva to each 1.9 plants in 1938 and 1.3 larvae to each plant in 1939. The total infestation (eggs and larvae) per plant at the apparent height of the season was .6 individuals on July 25, 1938 and 1.6 individuals on July 19, 1939.

It may be of interest to note that with timely and efficient spraying on a commercial scale, one application of poison controlled the insect in 1938, while two were necessary in 1939. Using ill-timed and inferior methods, some growers poisoned as many as four or five times in the latter year.

The eggs are laid mainly on the under surface of the leaf. Our records, taken in 1938, show that 90.5 per cent are deposited on the under surface. In this position, they are placed on an average of about one-half inch from the edge, the percentage which occurred on each fifth of the leaf from base to apex, the basal portion being the first fifth, were respectively 0, 5, 29, 45 and 21.

In regard to the position on the plant of the leaf selected for oviposition, a large number of records show that the upper third of the plant receives the largest percentage of eggs. The figures in percentage of total number of eggs are:—Lower third of plant—12; middle third—40; upper third—48.

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Jour. Econ, Ent., Vol. 31, No. 6, December 1938, pp. 706-712.

(2) Garman, H. and H. H. Jewett. The broods of the tobacco worms.
Kentucky Agricultural Experiment Station. Bull. No. 225, 1920.

FURTHER NOTES ON CORN BORER RESISTANCE IN HYBRID CORN WITH A BRIEF STATEMENT OF THE INFESTATION SITUATION IN ONTARIO IN 1939

By R. W. Thompson

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At the annual meetings of this society of the past two years, the writer has reported the results obtained in tests for corn borer resistance in corn hybrids versus popular standard varieties. In this paper the results obtained in the current year's experiments are reported.

The number of varieties and hybrids tested this year was increased to 61 compared with last year's total of 57. Since all of these were dissected, it was possible, in the time available, to obtain data from only two of the three experimental locations. Agronomic data, however, have been collected from Guelph, Ridgetown and Woodslea experimental plots, as in last year's experiments. Plot technique was identical with that reported last year, as was also the method of determining borer populations. The latter are reported on the basis of the average population of 10 stalks, taken from each variety and hybrid in two replicates. Two of the four men who did the dissecting last year were employed for this year's dissections. Last year a heavy storm in August had emphasized the stiffness of the hybrid stalks and the relative weakness of the standard variety stalks. In view of this fact a table showing the percentage of broken down stalks was included in last year's report. This year there was,

especially at Ridgetown, considerable reduction in the borer population and also freedom from heavy storms, with the result that there was not the contrast in breakage of stalks which occurred last season. Moreover, dry weather at a critical period, which was undoubtedly responsible for the decrease in borer population in the area surrounding Ridgetown, also caused corn to be shorter and to be dried out earlier than in a normal season. For these reasons no table is included in this year's report.

Table No. 1 shows the average number of borers per 10 stalks at Guelph for the 1939 plots. The borer populations for a similar number of stalks in 1938 are also shown for such varieties and hybrids as are common to both years. Examination of this table will show that while there are not the differences in borer populations between standard varieties and hybrids that occurred last year, a number of the hybrids have shown up moderately well for borer resistance throughout both years.

Table No. 2 shows the average number of borers per 10 stalks at Ridgetown and as in the Guelph table, the borer populations for 1938 also have been shown for such varieties and hybrids as were used both years. It will be seen that there was a much smaller borer population at Ridgetown than at Guelph. At Ridgetown between the most heavily infested corn and the lightest there was a difference of not more than two borers per stalk. Under such conditions it is difficult to demonstrate borer resistance clearly, but it has been observed that here also, as well as in the Guelph plots, a number of the more promising hybrids have again shown their superior stiffness of stalk even in the presence of larger average borer populations.

Common to both experimental locations was the promise which a number of the Wisconsin and several other hybrids gave for borer resistance, coupled with satsfactory agronomic features. Not all of the Wisconsin hybrids are in this class since both at Ridgetown and at Guelph this year, some have failed to produce cobs of sufficient size to compare favorably with those produced by some of the standard varieties. In this connection it should be re-emphasized that the factor of corn borer resistance alone will not suffice in the consideration of a hybrid or a variety, but agronomically the corn must be satisfactory for Ontario conditions year by year. It is considered that by the end of another season we shall have sufficient data to be able to draw conclusions as to the value of at least a few of the better hybrids.

TABLE No. 1

AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, GUELPH 1938 AND 1939

Variety or Strain	*Borers* 1938	1939	*Variety or Strain*	*Borers* 1938	1939
Salzer's N. Dakota	15	42	Minhybrid 402	19	29
Longfellow	21	42	Wood's Hyb. R. Sweeps	..	29
Wisc. 550 (110 day)	..	38	Golden Glow (Stewart)	23	28
Hybrid E5 (90 day)	..	37	Hybrid 355 S.F.	..	28
Excelsior	18	36	West Branch Sweeps	19	27
Cornell Hybrid 29x3	18	36	Hybrid D (100 day)	..	27
Wisc. 456 (100 day)	..	36	Hybrid 493	..	27
Hybrid E2	15	35	Hybrid G-8-2	..	27
Wisc. 525 (105 day)	18	35	Hybrid G 17	..	27
Wisc. 572 (110 day)	..	35	Golden Glow (Smith)	14	25
Minhybrid 403	..	34	Wisc. 625 (Wilcox)	..	25
W.C. Yel. D. (Bannister)	..	33	Hybrid M (105 day)	..	25
Burr Leaming	..	33	Wisc. 455 (105 day)	..	25
Hybrid K35	20	33	Wisc. 570 (110 day)	..	25
Wood's H.Y. Sweepstakes	..	33	Bailey	19	24
Hybrid A3 (95 day)	..	32	Hybrid F.B. (110 day)	10	24
Wisc. 620 (110 day)	12	32	Wisc. 644 (115 day)	12	24
Hybrid 202 (DeKalb)	13	32	Wood's Hybrid E. Yel.	..	24
Hybrid L4 (110 day)	11	32	Wood's Hybrid Y. Dent	..	23
W.C. Yel. D. (Cohoe)	16	31	Mich. Hybrid 561	12	22
Hybrid D4 (97 day)	..	31	Wisconsin No. 7	20	21
Minhybrid 301	15	31	Hybrid T.	16	21
Wisc. 531 (105 day)	16	31	Wisc. 645 (115 day)	13	21
Hybrid Illinois 751	8	31	Compton's Early	17	20
Hybrid 357 S.F.	..	31	Hybrid 420	10	20
Golden Glow (Cohoe)	18	30	Hybrid G-7-2	..	19
Minhybrid 401	23	30	Wisc. 606 (110 day)	14	18
Wisc. 615 (115 day)	12	30	Wisc. 603 (110 day)	..	16
Wisc. 625 (115 day)	11	30	Wisc. 646 (115 day)	..	15
Hybrid 200	11	30	Stowell's Evergreen	..	13
Hybrid F.K. (107 day)	..	29			

TABLE No. 2

AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, RIDGETOWN 1938 AND 1939

Variety or Strain	*Borers* 1938	1939	*Variety or Strain*	*Borers* 1938	1939
Longfellow	19	23	Wisc. 625 (Wilcox)	..	8
W.C. Yel. D. (Cohoe)	10	19	Wisc. 696 (120 day)	23	8
Minhybrid 401	..	18	Bailey	22	8
Compton's Early	11	17	Minhybrid 402	..	8
Hybrid L 4 (110 day)	12	17	Wisc. 625 (115 day)	16	8
Wisc. 550 (110 day)	..	16	Wisc. 644 (115 day)	5	8
Wood's Hyb. Y. Sweeps	..	16	Wood's H.Y. Dent	..	8
Golden Glow (Cohoe)	16	14	Wisc. 606 (110 day)	9	7
Wisc. No. 7	20	14	Minhybrid 301	12	7
Wisc. 695 (120 day)	..	13	Hybrid G-7-2	..	7
Wisc. 603 (110 day)	..	13	Hybrid M (105 day)	..	7
Hybrid G-12-2	..	13	Hybrid G-8-2	..	7
Salzer's N. Dakota	18	13	Hybrid F.K. (107 day)	..	7
Wisc. 678 (120 day)	..	13	Golden Glow (Smith)	9	7
Wisc. 570 (110 day)	11	12	Hybrid Illinois 751	23	7
Hybrid G-17	..	12	Wisc. 615 (115 day)	13	7
Mich. Hybrid 561	15	11	Hybrid F.B. (110 day)	..	7
Wisc. 680 (120 day)	7	11	Wisc. 676 (120 day)	..	7
Iowealth Hybrid A.P.	..	11	Hybrid 355 S.F.	..	6
Hybrid 200	12	10	Hybrid 493	18	6
Hybrid 420	14	10	Wisc. 645 (115 day)	25	6
Minhybrid 403	..	10	Wisc. 646 (115 day)	..	5
Hybrid G-15-2	..	10	Hybrid 202	15	5
Hybrid K 35	17	10	Wisc. 572 (110 day)	..	5
Hybrid 421	24	10	Iowealth Hybrid A.Q.	..	5
Hybrid 357 S.F.	..	9	Wisc. 675 (120 day)	..	4
Wisc. 620 (110 day)	16	9	Wisc, 655 (120 day)	..	3
Hybrid K 23	22	9	Hybrid T (110 day)	..	3

With regard to the general corn borer infestation situation in Ontario this season there have been decreases in the average stalk infestations of Essex, Kent, Lambton and Elgin counties. These counties form the western corn-growing area of the province. The spring clean-up was well done in all of this territory, but was of approximately the same standard as that which was maintained last year. Therefore, the factor responsible for the decrease appears again to have been the reduction in moisture at a critical period which occurred over this area. A similar condition, that of reduced moisture in late June, July, and early August, has occurred several times in past years and has been responsible for even greater reductions than was the case this season. The following table shows the average stalk infestations for these counties for the years 1937 to 1939 inclusive—

County	*1937*	*1938*	*1939*
Elgin	25.0	50.0	40.0
Essex	47.0	34.0	29.0
Kent	44.0	42.0	34.0
Lambton	31.2	41.0	38.0
Perth	20.0	...	45.0

In the above table the figures for 1937 and 1938 are shown for Perth county. It will be noted that considerable increase occurred in the average stalk infestation in this county. The fields responsible for this increase in stalk infestation were all in the northern half of Perth. In Simcoe county, especially in the neighbourhood of Barrie, at Lindsay, Peterboro, and in eastern Ontario from the St. Lawrence to Ottawa, borer populations were much higher than they have been in any previous year. In all of these areas moisture throughout the season but particularly throughout the latter part of June and July was apparently higher than normal. The result has been that stalk infestations as high as 85 per cent have been noted throughout these areas which are not in the territory where enforced clean-up is practised.

Increases have also occurred in the counties of Oxford, Waterloo and Wentworth but not to the marked extent noted in Perth county and other areas of increase. With the outbreak of war, scouting operations were brought to an end and counts were not made in all of the Niagara peninsula. Examination of odd fields has shown, however, that the stalk infestation has remained approximately the same in this part of Ontario. Moisture in the Niagara area was below normal throughout the critical period of corn borer life-history.

A TEST OF SODIUM FLUORIDE BAIT IN THE CONTROL OF THE EUROPEAN EARWIG IN ONTARIO

By A. G. McNally

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Preliminary tests made in 1938 (1) indicated that a poison bran bait used against the European earwig (*Forficula auricularia* Linn.) in Oregon and British Columbia might control with equal success a heavy infestation of this insect occurring at Ayton, Ontario. With this in view, tests were continued in 1939.

It was found impracticable to make a thorough study of the earwig at first hand since the writer was unable to spend sufficient time in Ayton

and felt it would be too dangerous to move living insects from the infested area to Guelph for study; lest they escape and start a new infestation in that area. Under the circumstances it was felt advisable to learn the habits of the insect from studies made in other areas and to compare these with personal observations made at Ayton.

In British Columbia (2) the female earwig lays about 60 eggs in a small nest an inch or two underground. These eggs are laid in very early spring and hatch in March or April. The young are tended by their mother in the nest for the first two weeks and then commence leaving the nest at dusk to hunt their own food. In the first two instars they are vegetarians; in the third and fourth they are carnivorous; and in the adult stage they are omnivorous. They reach this adult stage in early June and about a fifth of the females lay eggs for another brood the same season.

The instars of the European earwig can be readily identified by the number of joints in the antennae (3). The antennae of the first instar contain 8 segments, of the second instar 10, of the third instar 11, and of the fourth instar 12.

At Ayton in 1939 earwigs were found on June 8 in the first instar and a few of these were active at night; on June 15, after a cold spell, they were in the second and third instars, most of them still in nests below sod level in the ground. On June 20 most of those found were in the third instar with a few in the fourth. On June 23 they were in the third and fourth instars hiding beneath stones and in nests by day and venturing out at night. By July 3 nearly all had reached the fourth instar or the adult stage. They had left the nests and some had infested houses where they hid by day.

When observation showed that enough of the earwigs had survived the winter to cause a serious infestation again in 1939, it was felt that a test of poison bran bait should be made. Testing on a large scale was necessary because results of previous tests had agreed with the finding of other investigators that the migratory habits of earwigs precluded baiting on a restricted scale. It was felt that such a test would determine the effectiveness of the bait in this area and, if successful, might indicate the possibility of eradicating the pest, and it would also serve as an example to communities that might encounter a similar infestation.

The optimum time for baiting seemed to the writer to be after the earwigs had left their nests but before they had invaded the houses of the village. Accordingly when it was observed on June 23 that the earwigs were quite numerous above the ground and seemed to have vacated their nests, complete arrangements were made for baiting at the earliest date, which was June 26. The help of villagers was enlisted both to supplement the efforts of the three members of the Department available and to provide a test under conditions approximating those of a community effort. Unfortunately, however, the fact that earwigs had not yet invaded the homes caused a skepticism on the part of the villagers that caused them to withhold support and thus delay baiting. Just as this aversion

(1) Canadian Entomologist. Vol. LXXI. No. 5, May, 1939.

(2) Glendenning: "The European Earwig". Published by the Dominion Department of Agriculture, Entomological Branch.

(3) From data copied from a thesis of Dr. John Stanley and kindly forwarded by Dr. Geoffrey Beal.

was overcome, heavy rains set in and the baiting could not be commenced until July 3. By that date the earwigs had invaded a number of homes and no further difficulty was experienced in obtaining enough helpers.

On the day of the baiting (July 3) the bran was mixed during the afternoon. The Oregon formula was used:—2 lbs. bran, 12 ounces sodium fluoride, 2 quarts molasses, 6 quarts water (U.S. measure). A ton of bran, two drums of molasses, and 100 lbs. of sodium fluoride was sufficient for two baitings of this village which contains about one hundred rather scattered houses. The total cost for materials for two baitings was $65.52.

The village could be divided conveniently into fourteen sections so a man from each of these sections was made responsible for the complete coverage of that area. In the majority of the sections the man in charge had one helper. All the men were carefully shown how to spread the bait and were checked until their work was satisfactory. A quantity of bait was distributed at strategic points in the village and Mr. Goble of the Department of Entomology remained in charge of the reserve supply at a central depot. Professor Baker and the writer drove about, checking up on the baiting to ensure proper spreading and as complete as possible coverage of the whole area.

Preliminary tests had indicated that a second baiting following a few days after the first might give a much higher kill. We now encountered another important advantage of such a second baiting in that nearly all residents had become actively interested in the control of the insects and had searched out many previously unnoticed hiding places. As a result they were not only anxious to assist in baiting, but were able to distribute the bait much more effectively. Accordingly arrangements were made for another baiting two days after the first.

Early in the day of the second baiting the writer made a survey of the village. He decided that, in view of the heavy mortality from the first baiting, the outskirts could be omitted from the second. Heavily infested areas and those not properly attended to previously were marked for intensive baiting. Arrangements were also made to supply all persons interested with instructions and materials for adequate treatment of houses. In the remainder of the village, open land was to be baited lightly, and fences, trees and other likely hiding places were to receive special attention. Wherever possible bait was to be placed under boards or other cover where it might reasonably be expected to remain effective for several days.

The writer considered from the beginning that he would not be justified in attempting to secure an accurate statistical analysis of results. Such an analysis would require much time and effort, complicated as it would be by the size of the experiment, the wandering and hiding habits of the insects, and the influence of feeding on the dead by live earwigs and other predators. Moreover it was thought that, since the goal was practical control, a successful experiment must obtain a percentage kill high enough to be evident to even the most casual observer.

However, to obtain a rough comparison, counts were made just before the second baiting in three heavily infested areas in different parts of the village. In an hour and a half 1,560 earwigs were counted and of these 984 either were dead or showed distinct signs of illness, and 576 were still quite active.

Twenty-two days later Professor Caesar and the writer could find but 7 live earwigs in a three-quarter hour search. Further examination the same day of several other previously heavily infested points in the village showed the earwig population was so reduced that practical control of the baited area could not be doubted. Inquiry at a dozen homes previously heavily infested brought enthusiastic comments and unanimous agreement that the insects were cleaned out of the houses and were very rare outside.

At the time of baiting, the village of Ayton was the only area known to be infested. However, the Plant Protection Service of the Dominion Department of Agriculture, who had taken an active interest in the insect throughout, later in the season made a survey which showed not only some infested farms about Ayton, but a generally infested area in and around Neustadt, some six miles distant. (From their investigations it seems quite possible that Neustadt rather than Ayton was the area first infested.) Therefore the range of infestation practically eliminated whatever hope we had of eradicating this insect. Its future role in Ontario is, of course, uncertain. It may, like many other imported species, flourish for a time and then become less troublesome as natural factors gradually bring it under control. However, it has been shown that even where abundant it can, with proper co-operation of the community, be readily controlled at a low cost.

THE PLUM NURSERY MITE (*PHYLLOCOPTES FOCKEUI* NAL. AND TRT.)

By W. L. PUTMAN

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The eriophyid mite, *Phyllocoptes fockeui* Nal. and Trt., is an European species that has undoubtedly been established in Ontario for many years but has attracted little attention because the injury it produces has probably been confused with that of the potato leafhopper, *Empoasca fabae* Harris. As the species is of economic importance in Ontario only on plum nursery stock, the common name of plum nursery mite is proposed.

The species was identified by Dr. A. M. Massee of East Malling, England. Investigations on its biology and control were carried on during 1937 to 1939 at the Dominion Entomological Laboratory at Vineland Station, Ontario, under the direction of Mr. W. A. Ross. The control studies are still in progress.

HISTORY AND DISTRIBUTION

Phyllocoptes fockeui was first discovered by Trouessart in France, according to Nalepa (4), who later found it in Austria, and Massee (3) states that it is very common in England. In Ontario, it was first recorded by Ross (5) in 1928. In North America, it has apparently not been found outside of Ontario; Dr. H. E. Ewing, in a personal letter, states that there are no records of the species in the National Collection at Washington.

HOST PLANTS AND INJURY

The principal host of *P. fockeui* is European plum. Certain varieties notably Damsons, appear to suffer somewhat more severe injury but practically all varieties may be badly injured and such differences as have been

noted may have been the result of variation in time of infestation rather than varietal susceptibility. Myrobalan plum, (*Prunus cerasifera*), used as rootstocks in nursery propagation, and the purple-leaved variety of this species known as *Prunus pissardi* are usually only lightly infested and no visible injury has been noticed. Japanese and American varieties are completely immune; an occasional mite was found on them, apparently blown from adjacent European stock, but no evidence of breeding or injury could be seen. Nalepa (loc. cit.) records the species on red or sour cherry in Europe.

The mites live chiefly on the lower surface of the leaves and, as extensive feeding is done only on young foliage, injury is confined chiefly to terminal growth. While the species is frequently common on mature trees, particularly on watersprouts and terminal shoots, serious injury has been noticed only on nursery stock, with its large proportion of tender young growth.

The injury is characterized by curling and dwarfing of the foliage and by a brown or bronze scurfy condition of the lower epidermis. The effect may usually be distinguished from that produced by the potato leafhopper by the distortion of the very small terminal leaves, particularly by the curling of the lateral margins rather than the tip, and by the scurfy lower surface; but as leafhopper injury is almost universally present, it is often difficult to determine what proportion of the injury is produced by each pest. According to Massee, the species sometimes causes the foliage to assume a silvery appearance; this type of injury has not been noticed in Ontario.

Description

Adult — The adult mites are minute vermiform creatures with two pairs of legs, just within the limits of unaided vision when placed on a black background but quite invisible on foliage. Females average about 157μ in length by 52μ in width; males are slightly smaller. Newly matured adults are pale yellowish, becoming brownish yellow with age. A detailed description is given by Napela.

Egg—The egg is flattened and slightly elliptical and glued closely to the leaf. When first laid it is translucent and very difficult to locate, becoming somewhat whitish just before hatching. Dimensions are approximately 49 by 52μ.

Immature Stages—The two immature stages are usually designated in the literature as the larva and nymph, although both have essentially the same structure as the adult. King (2) found three stages in *Eriophyes carinatus* Green, but in other species, including *Eriophyes tristriatus* Nal. studied by Hassan (1) and *Phyllocoptes oleivorus* Ashm. by Yothers and Mason (6), only two have been found. This point was carefully checked in *P. fockeui* but only two stages could be distinguished.

The larva is whitish and somewhat translucent, very similar to the adult but with a relatively stouter thorax and lacking certain setae. When nearly hatched it measures about 67 by 25μ.

The nymph is pale yellowish white and its form more closely approximates that of the adult. There is considerable variation in size; the length varies from 105 to 130μ; width from 37 to 42μ.

LIFE-HISTORY

Methods of Study—The mite was reared in a screened insectary on potted Myrobalan plum seedlings. As this species is not the preferred host, the mite being normally much more abundant on the common European varieties, there is a possibility that the life-history data obtained may be somewhat abnormal, but it is felt that they at least approximate those in the field. European stock was not suitable for rearing purposes because of the pubescent lower surface of the leaves. The mites were confined within small celluloid cells, about an eighth of an inch in diameter. Each cell was cemented in a strip of celluloid attached at one end to another piece bearing a cotton or sponge rubber pad. A strip of aluminum was also attached to the celluloid strips and supported the cell from a stake pushed into the soil of the pot. A young leaf was placed between the celluloid strips with the lower surface against the cell and the strips fastened together with paper clips. Vaseline was smeared about the upper edge of the cell, more to prevent contamination from outside than to retain the mites placed within.

The procedure usually followed was to place several adults within a cell and remove them the following day after a few eggs had been deposited. On hatching, all but one or two of the larvae were eliminated and the survivors followed through their life cycle. In working out certain details of the life-history individual mites were transferred but a very high mortality resulted which limited the use of this method. The technique used was very successful for determining the duration of the immature stages, as the latter did not move about to any extent, but the adults were much more active and the majority eventually wandered out and became stuck in the vaseline, so that only a very few of those reared yielded data of any value on length of life and on oviposition. Another complication was that the sexes could not be distinguished with certainty in the living state, but could only be determined by mounting the mite in potassium hydroxide solution and examining it under high power.

Incubation Period—The eggs required 2 to 15 days to hatch, depending on the temperature; in the warmer part of the season, most of them hatched in 3 to 4 days. The mean incubation period through the season, based on the combined records for 1938 and 1939, is given in Table No. 1.

TABLE No. 1—INCUBATION PERIOD

	No. Eggs	*Days*	*Mean days*
April	1		15
May	2	5	5
June	39	2-6	4.3
July	41	3-5	3.7
August	56	2-5	3.3
September	19	3-8	5.2
October	2	4-10	7

Larval and Nymphal Periods—The larval and nymphal periods each lasted from less than one to four days, or considerably longer in very cold weather. The former is somewhat the longer, averages of all rearings being 2.1 days for the larval and 1.7 for the nymphal period. The total developmental period from hatching to maturity occupied 2 to 18 days, usually requiring 3 to 4 days in midsummer. The mean period for the various months is shown in table No. 2.

TABLE NO. 2 — DURATION OF LARVAL-NYMPHAL PERIOD

	No. Reared	Days	Mean days
May	5	9-18	12.8
June	26	4-8	5.0
July	42	3-5	3.7
August	70	2-5	3.3
September	30	3-8	5.5
October	2	7-9	8

Just before moulting, both larvae and nymphs assumed a quiescent condition lasting from a few hours to one or two days, the legs being drawn in and the cuticle stretched tightly over the body.

Length of Generation—The time required for completion of the life cycle, calculated from hatching of the larvae of one generation to that of the next, varied considerably as a result of differences in the length of the preoviposition period probably caused by improper rearing conditions. Excluding obviously abnormal examples, a generation was completed in 6 to 22 days, the majority falling within a range of 7 to 12 days. Table No. 3 shows the monthly variations in the length of the period.

TABLE NO. 3 — LENGTH OF GENERATION

Month Hatched	No. Reared	Days	Mean days
May	4	14-22	18.7
June	21	8-18	11.4
July	21	7-12	8.3
August	34	6-14	9.0
September	16	12-20	14.2

Fecundity and Longevity—It was very difficult to get satisfactory records of oviposition as the mature mites tended to wander from the cells, especially if the leaves on which they were confined were too mature. The greatest number of eggs deposited by one female was 79; others laid 68, 65, 63, 59 and 58 each, while the remaining 112 females from which records were secured produced anywhere from 1 to 50 eggs. Many others did not oviposit at all. These data are too few and unsatisfactory to indicate the normal complement.

Most females began to oviposit within a day after maturity; in early spring and late fall this period might be extended to 3 days or more. Eggs were normally laid at the rate of one to 5, usually 2 or 3, per day. Many irregularities, probably the effect of confinement, were noted; occasional females did not produce eggs for a week or more after maturity, and in other cases breaks of several days occurred during which no eggs were laid.

Most of those females producing more than 50 eggs lived from 20 to 31 days after maturity. In late fall, the life span was more prolonged, a few individuals living 40 to 44 days.

The length of life of males was more difficult to determine as it was necessary to kill and mount them to check the sex. One individual lived 20 days during July and August and another 25 days in August and September.

Sex Relations—Females are normally considerably more abundant than males although rarely the converse may be the case on old leaves after most of the females have migrated to winter quarters. Counts made on

individual leaves showed that males formed anywhere from 10 to 60 per cent, but usually about 20 to 30 per cent, of the population.

Of 118 offspring reared from fertilized females, 32, or 27 per cent, were males.

Eggs from unfertilized females produced only males while those from fertilized parents included both sexes. In some experiments, the early progeny of virgin females consisted as usual of males only, but eggs laid after maturity, but usually appeared to occur very soon after the final males were apparently fertilized by their own male offspring.

The process of coition was not observed. It can take place any time after maturity, but usually appeared to occur very soon after the final moult. Males were frequently seen crawling about over female nymphs in the quiescent stage just before the last moult, but, as the external genital opening is not present in the nymphs, mating cannot take place before maturity.

All males die in the fall and only females survive the winter. As both sexes were reared from the earliest eggs laid by overwintering females, the latter are presumably fertilized in the fall before going into hibernation.

Seasonal Life-History—The females overwinter chiefly in the cavities of dead or shrunken buds where they may occur in clusters of 20 or more, and to some extent in crevices of twigs and bark. Some enter healthy buds where they may be found just within the margins of the outer scales, but the latter are wrapped too tightly to allow the mites to penetrate further and all those examined in such situations have been dead by spring. That some survive in healthy buds, however, is suggested by heavy infestations developing on stock of certain varieties the next year after budding, the buds apparently having been taken from badly infested trees. There is also a possibility that some overwinter about the trunks below the soil surface, although experimental evidence was not obtained on this point.

The mites begin to leave the buds when the latter have partly expanded. In 1938, an exceptionally early season, this occurred about April 14, while in 1939, which may be taken as a normal season, the first migrating mites were noticed on May 5. They soon scatter over the expanding foliage and apparently feed for a few days before beginning to oviposit, as the ovaries are undeveloped at the time of leaving winter quarters. Immature stages of the first generation were not found in the nursery owing to the very small number of mites in proportion to foliage area, but were easily obtained in cells in the insectary. In 1939, the first larvae hatched on May 19 and adults matured on the 27th. Early in June of both years small colonies could be found on the lower surface of the leaves among the pubescence along the midrib, and from then on the infestation developed very rapidly. In 1938, it was calculated that 15 generations were produced during the season; in 1938, 13 or 14. As females may live more than twice the average length of a generation, only part of these would be complete.

In most seasons, the population reaches its maximum during the latter part of July, when slowing of tree growth and activity of predators begin to limit its increase. The greatest amount of injury is usually produced during late June and July. In seasons such as that of 1939, however, when heavy midsummer rains prolong the growing season, the mites may remain destructively abundant well into September.

Females of the overwintering form may be distinguished under the microscope by the absence of well-developed ova which are conspicuous in actively breeding females. They were first found in the buds on August 5 in 1937 and August 8 in 1938, but may have entered several days previously; in 1939, they began to enter some time between July 17 and 25. It was quite apparent both in the nursery and insectary that hardening of the foliage, rather than temperature, is the stimulus which leads to the production of the hibernating forms. The latter are first produced as soon as the foliage begins to harden, which occurs during the hottest part of the summer. In the insectary, it was noticed that females maturing on old hard leaves seldom produced eggs but soon left the rearing cells. Examination of many of these individuals proved then to be overwintering forms.

As long as any succulent young growth remains the mites continue to breed freely on it until very late in the season. In both 1938 and 1939 all stages could still be found on November 1, after 3 degrees of frost.

Natural Control

Predators—A predaceous mite, *Seiulus sp.**, is by far the most effective enemy of the plum nursery mite, but its numbers vary greatly. In 1937 and 1938, it appeared in numbers about the end of July, just after the most rapid development of the nursery mite had been checked by cessation of tree growth, and soon reduced the remaining population to insignificant proportions. In 1939, however, the predator was not noticed until August 29, too late in the season to be of any value. Unfortunately, this species never appears to be abundant during June and July, when most injury is produced, and so its effectiveness is limited.

Young nymphs of the anthocorid *Orius insidiosus* Say were frequently found attacking the nursery mite, and larvae of two or more species of cecidomyiids also fed upon it to a certain extent, but none of these predators were ever sufficiently abundant to be of any practical importance.

Winter Mortality—Only a very small percentage of the hibernating mites survive the winter; this is especially true of those in more exposed situations such as beneath outer bud scales. Heavy mortality, probably the effect of desiccation, also occurs during the summer between the time of entry into the buds and the advent of cold weather.

Precipitation—The direct effect of precipitation upon the mite is not known but it is of great importance insofar as it affects the growth of the nursery stock. Dry weather, by checking tree growth and hastening maturity of the foliage, will soon reduce the prevalence of the mite, and conversely, heavy rainfall in midsummer will prolong the period when succulent foliage is available and lead to severe infestations in August.

Dissemination

The mite commonly occurs in small numbers on Myrobalan plum, and there is little doubt but that it is annually introduced on Myrobalan seedlings imported from Europe as rootstocks for the propagation of other varieties. Another probable source of nursery infestation, previously suggested, is the use of buds containing hibernating mites.

To learn whether insects carried the mites a few flying insects were swept from above a row of badly infested plum stock. In the small collection of 15 froghoppers (*Philaenus leucophthalmus* L.), 10 potato leafhop-

* Determined by Dr. H. E. Ewing, U. S. Bureau of Entomology.

pers and a few small chironomids were 4 plum nursery mites. In view of the great abundance of these and other insects in nurseries, they must be important agencies of dissemination. The mites' habit of clinging with the anal sucker to any object which touches the caudal end makes them especially liable to be picked up by other organisms. Massee quotes several authorities who found that the currant bud mite, *Eriophyes ribis* Westw., was transported by many insects.

Wind is probably another very important factor in the spread of the mite.

An Associated Eriophyid

Occasional individuals of another eriophyid, *Epitrimerus gigantorhynchus* Nal.*, were scattered among much larger numbers of *P. fockeui* on European varieties, and a few small pure colonies were found on Myrobalan plum. The association of this species with *P. fockeui* was first discovered by Nalepa (loc. cit.). It is easily distinguished from the latter species by its much larger size (length 250μ), stouter body, with deep reticulate sculpturing on the thoracic shield, and whitish or lavendar colour. It appears to be too rare to be of any economic importance.

Summary

The eriophyid mite, *Phyllocoptes fockeui* Nal. and Trt. for which the name of plum nursery mite is proposed, is a serious pest in Ontario on plum nursery stock of European varieties. Injury is characterized by curling and dwarfing of the foliage and by a brown or bronze scurfy condition of the lower epidermis. Females hibernate in the buds and emerge when the latter are bursting. A generation may be completed in 6 days in very warm weather and there may be as many as 15 generations during a season. The species is arrhenotokously parthenogenetic, unfertilized females producing only males.. Winter mortality and the predaceous mite *Seiulus* are important factors in limiting its increase.

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* Determined by Dr. A. M. Massee.

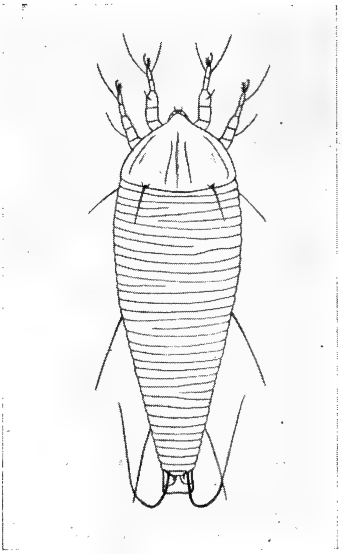

Fig. 1

Fig. 2

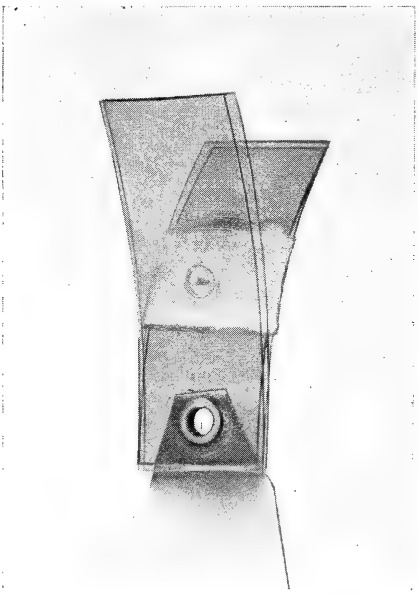

Fig. 3

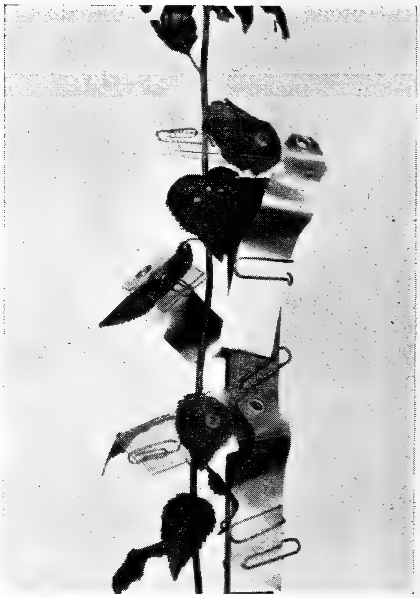

Fig. 4

Fib. 1—Adult of plum nursery mite (Phyllocoptes fockeui Nal. and Trt.).

Fig. 2—Injury produced by plum nursery mite.

Fig. 3—Celluloid cell used for rearing nursery mite.

Fig. 4—Rearing cells attached to leaves.

THE PLUM LEAFHOPPER (*MACROPSIS TRIMACULATA* FITCH) IN ONTARIO

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The plum leafhopper, *Macropsis trimaculata* Fitch, has been shown by Kunkel (4), Hartzell (2) and Manns (5) to be the insect vector of peach yellows and little peach, two extremely important virus diseases of the peach in the Niagara district of Ontario. Hartzell (3) has published an account of the bionomics of the species as it occurs in southern New York state. The notes which follow were prepared from original observations made during the years 1936 to 1939 in the Niagara Peninsula. All rearing was carried on in a screened insectary at Vineland Station.

Distribution.—According to Breakey (1) this leafhopper has a wide distribution in northeastern North America. Provencher lists the species from Quebec in his "Petite Faune Entomologique du Canada" published in 1886, and records in the Canadian National Collection show that the insect has been taken at Strathroy in western Ontario (1935), in Prince Edward county and the Ottawa region in eastern Ontario (1914 and 1906), and in the Niagara Peninsula.

Hosts.—In the years during which the species was studied it was always most abundant on wild plum (*Prunus americana* Marsh), being found in small numbers on this host during periods of scarcity when it could not be located on others. Cultivated plums, both European and Japanese varieties, were also quite heavily infested when the insect was generally prevalent. In 1936 European varieties appeared to be somewhat more favoured, although this is contrary to the experience of American workers. The disappearance of the insect in later years prevented further studies of host preferences. The leafhopper also breeds on peach in small numbers. In the course of observations made during 1931 to 1935 in connection with another project both nymphs and adults were found each year in a peach orchard at Grimsby Beach and occasionally in other orchards at St. Davids and Vineland Station. The hoppers were always comparatively scarce on peach and did not average more than one or two per tree at any time. Other species of *Prunus*, including wild black cherry (*P. seretina*) and choke cherry (*P. virginiana*), growing in the vicinity of infested plums were examined but no hoppers were found.

While wild plum is most heavily infested it is too scarce in the peach-growing areas to be ordinarily of any importance as a source of leafhoppers for virus transmission; but as the insect may persist in small numbers on this host during times of general scarcity when it has apparently disappeared from cultivated orchards, clumps of wild plum may be very important as foci of infestation while the insect is becoming reestablished.

Prevalence in the Niagara Peninsula.—In 1936 *M. trimaculata* was common on all wild plum trees and present in all but one of 11 plum orchards examined in the Niagara Peninsula between St. Davids and Grimsby. In two orchards it was especially abundant, the most heavily infested being a block of seedling European plums about eight years old at Vineland Station, and the other an old bearing orchard at Jordan Station containing both European and Japanese varieties. A few were also taken on peach trees at Jordan Station, Vineland and Grimsby.

For the years prior to 1936 little information is available; but that already given on the insect's occurrence in peach orchards from 1931 to 1935, and its relative abundance on wild plum at St. Davids during the same period, suggests that the species had been prevalent, at least in some localities for several years.

In 1937 it was practically impossible to find the insect anywhere in the Peninsula. Only about 25 specimens were seen during the season, all from one clump of wild plum situated on the escarpment two miles southwest of Vineland. No explanation can be offered for the sudden disappearance of the insect. Presumably the eggs failed to hatch; this was certainly true of those laid on wild plum trees by caged adults.

The leafhopper was still very scarce the following year, although small numbers appeared at St. Davids as well as at Vineland. In 1939 a few were taken at Queenston, St. Davids, Vineland and Grimsby, so it would appear that the species is gradually recovering, but it will probably require several years to regain its original numbers and distribution.

The terms "abundant" and "common" as applied above to the plum leafhopper are only relative; in the writers' experience it has always been comparatively scarce and never abundant in the sense with which this term is generally used in reference to a species of economic importance.

Another species, *Macropsis insignis* Van Duzee, very closely allied to *trimaculata*, appeared on wild plum at Queenston and a few other localities in 1938. In 1939 it was extraordinarily abundant on a small group of wild plums at Queenston, a hundred or more nymphs frequently being clustered on a branch a couple of feet long. The habits and life history of *insignis* appear to be very similar to those of *trimaculata*.

Egg.—The elongate oval eggs, about 0.6 mm. in length and pearly white in colour, are laid in one to three-year-old twigs or occasionally in older wood. They are inserted obliquely and diagonally within the bark, either upward or downward, and to the right or left at an angle of about 45 degrees to the axis of the twig. The egg lies entirely within the cortex and phloem with the outer end just below the surface of the bark and the inner at or near the cambium. When growth of the twig occurs after insertion of the egg the inner end may finally lie in a shallow depression of the wood formed by later growth of the xylem about it. On young twigs with the epidermis still intact a very small scar, enlarging with age (Plate 1, Fig 2.), and sometimes a slight swelling, marks the position of the egg, but on rough-barked wood the latter cannot be located.

Hatching of Eggs.—In 1936 eggs hatched from May 13 until May 30, and in 1937 from May 19 to June 8. The nymphs emerge from the eggs during the morning hours as a rule and may hatch at temperatures as low as 41 degrees F. The first eggs hatched when apple buds were in the pink stage, and most of the nymphs appeared during apple blossom period. A summary of hatching during three years is given in Table 1.

TABLE 1—*Hatching Period of Plum Leafhopper Eggs*

	1936	1937	1938
First eggs hatched	May 13	May 19	May 18
25% of eggs hatched by	May 15	May 29	May 21
50% of eggs hatched by	May 18	May 31	May 23
75% of eggs hatched by	May 22	June 1	May 26
100% of eggs hatched by	May 30	June 8	June 1

Method of Rearing Nymphs.—The newly hatched nymphs were transferred by means of a camel-hair brush to small Myrobalan plum and peach trees planted in five inch plots (Plate 1 ,Fig. 6.). In some cases the plants were covered with lantern globes, but in others they were left uncovered. *Macropsis trimaculata* was not easily reared in the insectary, many of the nymphs being lost particularly during the first instar. The greatest success was secured when the nymphs were moved to new plants just after hatching. It was also important to use the right type of plant; if the growing points were removed, or they were at all woody and hard, the insects invariably succumbed or wandered off. The use of vigorous plants with plenty of succulent growth was essential in successfully rearing the nymphs. Mortality was much higher on peach than on plum.

First Instar Nymph.—When the nymph first hatches it is whitish in colour and quite conspicuous, but gradually darkens to brown in a few hours. The intensity of colour varies considerably in this and later instars. The abdomen is crested, each segment possessing a prominent tooth projecting backwards; this crested and toothed abdomen is characteristic of *trimaculata* nymphs of all instars.

Second Instar.—This instar is dark brown and very short and stout with a prominent thorax and short transverse head. The metathoracic posterior margin is definite in outline with the wingpads only slightly extended.

Third Instar.—Older specimens are a uniformly olive gray in colour with some individuals much darker than others. The shape is similar to that of the second instar but more robust. The wingpads are somewhat more conspicuous, extending to the first abdominal segment (Plate 1, Fig. 3.).

Fourth Instar.—The general coloration of this instar is similar to that of the bark of year old plum twigs. The head and thorax with the wingpads are pale olive; the basal part of the abdomen reddish-brown, with the three terminal segments olive green shading into brown on the last. The legs are pale grayish or greenish brown. Some of the nymphs are more uniformly coloured, being largely brown with a greenish tinge. The wingpads reach half way over the second adbominal segment.

Fifth Instar.—The wingpads are conspicuous, reaching over the third abdominal segment, and vary from green to greenish yellow in colour. The coloration of the body varies considerably, but is generally reddish brown with yellowish brown markings. The eyes are pinkish. The general appearance is one of robustness; the crested and toothed abdominal segments giving a foreshortened appearance (Plate 1, Fig. 5).

Moulting.—All of the instars, as a rule, migrate from the twigs to the underside of the foliage, usually along the midrib, when about to moult. The cast skin (Plate 1, Fig. 1), greyish brown in colour, is left attached to the leaf, but a moderate breeze will blow it away. The final exuviation occurs, as in previous moults, along the midrib of the underside of the leaf. As the adult leafhopper forces its way out of the exuviae there are two ball-like protrusions prominent on the thorax. These are the unfolded wings, which in a few minutes are extended to their normal shape, and are folded along the dorsal surface in the usual way. The insect soon takes on its reddish brown colour, requiring about one hour on a warm day to attain full pigmentation.

Duration of the Instars.—During the three years this insect was studied under insectary conditions 83 leafhoppers were reared from eggs to adults using the method already described. Nymphs lived anywhere from 39 to 63 days, the average in 1937 being 42.2 days for 32 individuals. The length of the five instars as determined during 1936, 1937 and 1938 are presented in table II.

TABLE II—*Duration of Nymphal Instars*

Instar	*Max. length. Days*			*Min. length. Days*			*Aver. length. Days*		
	1936	1937	1938	1936	1937	1938	1936	1937	1938
First	17	11	15	10	5	11	13.1	7.1	13.5
Second	12	11	8	7	6	6	9.2	7.8	7.1
Third	13	11	9	7	6	6	9.6	7.9	7.0
Fourth	14	12	13	9	5	5	10.4	8.6	7.0
Fifth	14	14	16	9	7	9	11.6	10.8	12.5
Nymphal life	63	50	47	46	39	40	53.8	42.2	45.6

Span of Moulting—The seasonal occurrence of the various nymphal moults in the development of *M. trimaculata* to maturity was worked out from the life history records as follows (Table III):

TABLE III—*Time of Moulting*

	1936	1937	1938
Occurence of first moult	May 26-June 4	May 30-June 13	May 18-June 12
Second moult	June 6-June 12	June 7-June 21	May 27-June 19
Third moult	June 14-June 23	June 14-July 2	June 6-June 26
Fourth moult	June 26-July 4	June 21-July 10	June 13-July 7
Fifth moult	July 8-July 17	July 4-July 17	June 20-July 19
Nymphs	May 13-July 17	May 19-July 17	May 18-July 19

Habits of the Nymph.—This species of leafhopper is to be found on the twigs and small branches of the host plant, and very rarely on the foliage. The nymphs congregate on the twigs usually at the junction with larger branches, or hidden in the cracks and crevices of the spurs or axils of the leaves, where they remain except at moulting time when they migrate to the foliage. It should be mentioned they are very difficult to locate on the twigs, as their coloration approximates that of the bark, and as their triangular form and habit of clinging closely to the twigs make them resemble bracts or buds.

The Adult.—The general colour of the female leafhopper (Plate 1, Fig. 4) is a dull reddish brown, while the male is darker and nearly black. The female has three hyaline spots on each elytron, two of which are very distinct, and the male one conspicuous each elytron, two of which are very distinct, and the male one conspicuous spot and two others not as clearly defined. The pronotum of the female is dull yellow-brown, with a dark patch on the disc; that of the male is a darker brown. The scutellum is grey, set with areas of dark brown with nearly black triangular areas at the outer edges. The face is lighter than the general colour, approaching yellowish brown, with the frons in the female more yellowish than that of the male. In size the males are slightly smaller than the females, which average 4.5 mm. in length from pinned specimens.

Habits of the Adult.—Like the nymphs, the adults are to be found mainly on the twigs and branches of the tree, but they may rest on the petioles and leaves occasionally. It has been observed that in extremely hot

weather they will gather on the underside of the foliage on the shaded side of the tree. They may take to flight if disturbed, especially on warm days, but usually remain on the twigs, crawling out of sight behind the limbs at the slightest movement on the part of the observer. The adults are equally as hard to locate as the nymphs, not only because of their protective coloration, but also because they are usually far from abundant.

Feeding of Adults.—This insect differs from the more familiar species of leafhoppers by feeding exclusively on the younger twigs and to some extent on leaf petioles. The feeding punctures are at first invisible but may later give rise to small lenticel-like structures. As very large numbers of *M. trimaculata* have never been seen in orchards it is not likely that any serious direct injury is done to plum or peach, but the fact that the insect is capable of transferring peach yellows and little peach from tree to tree makes the feeding a very important matter.

Sex Ratio.—In 1936 there were three females to every two males in the reared material, and in the general orchard collections amounting to some 390 specimens 52.6 per cent were females. During 1937 males and females appeared in equal numbers in the rearing cages. No information on the sex ratio in the field was obtaianed that year because of the extreme scarcity of the insect.

Copulation.—Observations on copulation were quite fragmentary, altogether about nine pairs being noticed in the insectary during the 1936 season, and five pairs in 1937. It occurred from two to 49 days after maturity of the female. In 1936 copulation was in progress in both the orchard and insectary during the early part of July. A period of 3 or 4 weeks followed during which no mating was observed, and then adults were collected in copula in the orchard on August 7, and one was observed in the insectary. In 1937 it was shown that females may copulate more than once, as was suspected from the records of 1936. On July 12, four days after a male and female were placed together, copulation took place, and on August 26, 45 days later, the same female copulated again with the same or another male present in the cage.

Reproductive Capacity.—The hatching of eggs deposited on potted plum and peach seedlings in the insectary during the season of 1936 was recorded during May of the following year. Out of 60 plants on which females had been caged only five yielded nymphs as tabulated in Table IV.

TABLE IV—*Reproductive Capacity of Females*

Plant No.	Females in cage	Eggs hatching	Average per female
2	2	37	19
4	2	8	4
7	1	35	35
11	1	12	12
6	1	1	1
	7	93	13

On examining the twigs after hatching was completed for the season numbers of eggs were located which had not hatched, some of which appeared to be fresh-looking while others had collapsed, turned brown and dried up. In 1937 a single female laid a total of 57 eggs which gave rise to nymphs the following spring. This is the largest number of viable eggs so far secured from one individual.

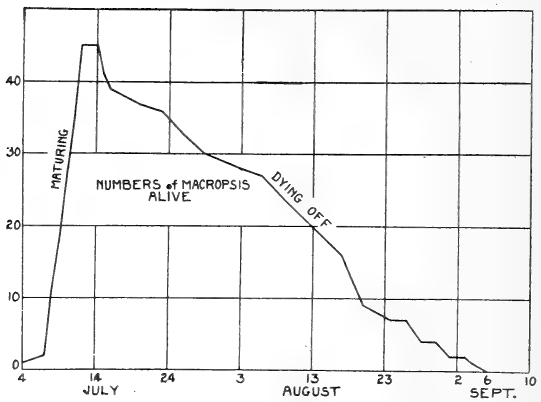

Fig. 1—Longevity of Plum Leafhopper

Length of Life.—In 1936 adults confined in lantern globe cages on peach seedlings lived from 2 to 66 days, the average of 136 individuals being 20 days. In this season one leafhopper lived until September 25 in the cages, but we were unable to find adults on the trees after September 1. During the following season leafhoppers survived as long as two months on potted plums but all had died by September 6. The accompanying graph (Text fig. 1) illustrates the length of life of plum leafhoppers in insectary cages during the 1937 season.

The mortality rate for two years is given below (Table V).

TABLE V—*Mortality of Adults*

	1936	1937
25% of adults dead by	July 14	July 25
50% of adults dead by	July 22	Aug. 10
75% of adults dead by	Aug. 16	Aug. 19
90% of adults dead by	Aug. 24	Aug. 30
95% of adults dead by	Sept. 1	Sept. 3
100% of adults dead by	Sept. 25	Sept. 6

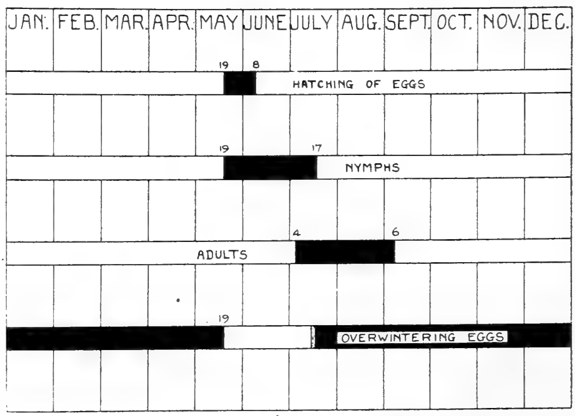

Fig. 2 Life History of Plum Leafhopper

Life History Summary.—There is but one generation in a year, with the insect passing the winter in the egg stage. Eggs commence hatching about

mid-May, and continue until the first week of June. The nymphal period covers a little more than two months, mid-May to mid-July, the insects moulting five times. Adults start to mature in early July and continue to appear until about July 15. They live from a few days to over two months, being present in the trees during July and August. Most of them are dead by the first of September but occasional individuals may live until September 25. The life history in diagrammatic form is appended (Text fig. 2).

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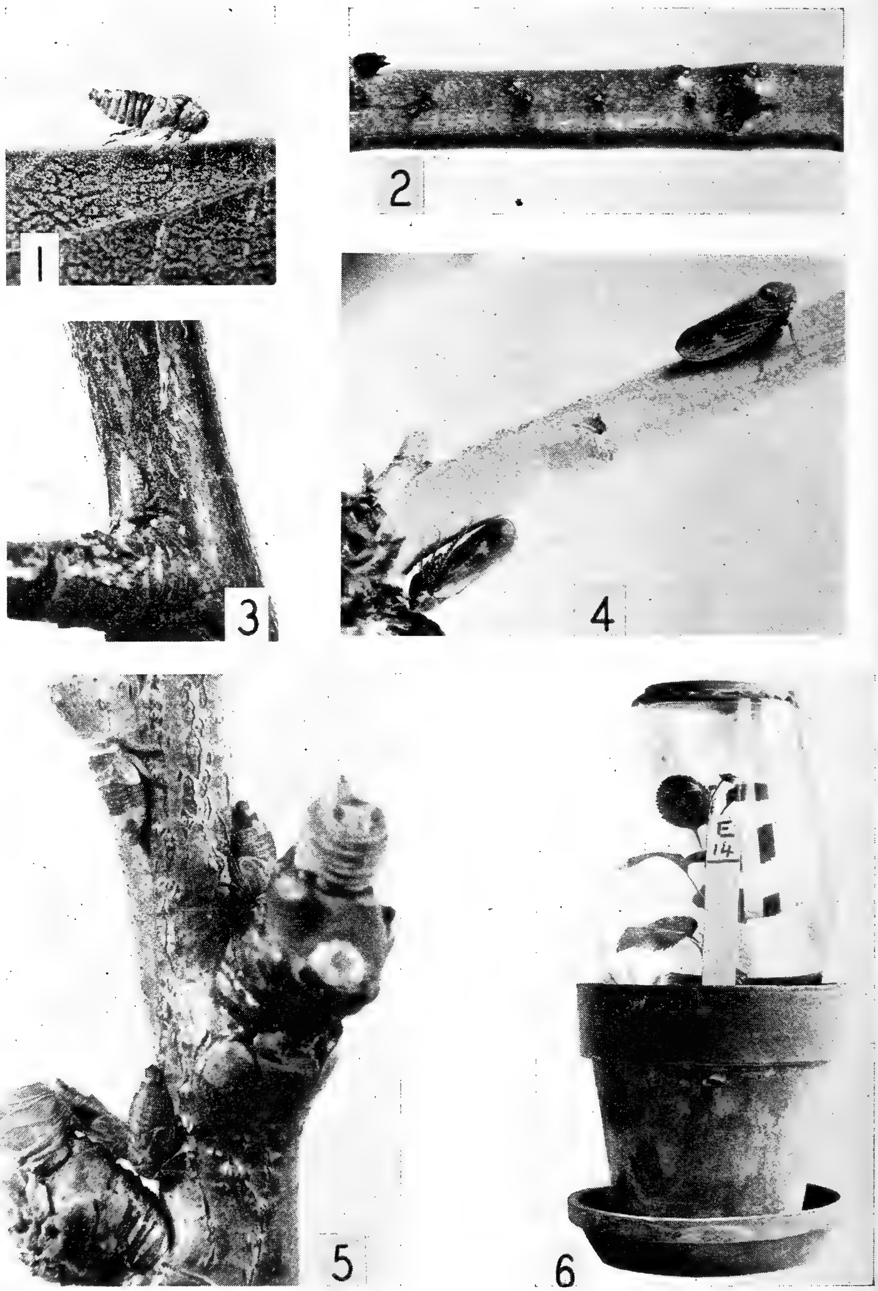

PLATE 1

PLUM LEAFHOPPER

Fig. 1.—Fifth exuviae on midrib of leaf. Enlarged
Fig. 2.—Egg punctures on peach twig, after hatching. Enlarged
Fig. 3.—Third instar nypmh in characteristic position on plum twig. Enlarged
Fig. 4.—Adult female plum leafhoppers. Enlarged
Fig. 5.—Fifth instar nymphs on plum twig. Enlarged
Fig. 6.—Cage used in rearing plum leafhopper.

(Photographs by T. Armstrong.)

NOTES ON *LAMPRONIA RUBIELLA*, BJERK. A RASPBERRY PEST NEW TO NORTH AMERICA

By C. W. B. MAXWELL and F. T. LORD
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In the spring of 1936, small lepidopterous larvae were found feeding within undeveloped and partially developed raspberry buds in a plantation near Fredericton, N.B. by the writers. Moths originating from this infestation were forwarded to Ottawa, and finally identified by Mr. August Busck of the United States National Museum, as *Lampronia rubiella*, Bjerk. This is the first record of the occurrence of this insect in North America.

In the early summer of 1939 the insect was found by officials of the Plant Protection Division at various points along the St. John River valley between Keswick and Kingston, a distance of some seventy miles. It was also found in Prince Edward Island at this time.

The plantation near Fredericton consists of ten rows of Viking and seven rows of Newman raspberries. The infestation seems wholly confined to the first five or six rows of the Newman variety, only a few larvae being found in the Viking. When located during scouting operations the variety infested was usually Newman and it is therefore believed this variety is preferred. The insect was also found on wild canes by the roadside on a few occasions.

Type of Injury.—Newman canes in the plantation of original discovery were somewhat dwarfed in height and presented a thin foliage appearance, suggesting a lack of fertilizer. It is believed this infestation has been in existence for at least two years preceding 1936. Larvae were first seen actively crawling upon the canes on April 26, 1938 and on May 9, 1939. They were then not more than three-sixteenths of an inch in length, of a bright red color with a dark or dull black head capsule. It was apparent that the larvae did not at once bore into the nearest buds as practically every bud on a cane might be examined several times by the insect before one was finally bored into. Larvae were seen to begin boring operations and suddenly stop to proceed to other buds. When a bud was finally selected, the larva bored into it from the tip or from a point near the tip and in approximately ninety minutes was completely out of sight.

Soon after becoming infested a bud may develop to such an extent that the entrance hole, always very inconspicuous, becomes hidden. The larva can then be detected only by opening of the bud. Later, the larva may work down to the base of the bud and bore in as far as the pith of the cane. It may then be seen by removing the bud. As the pupation period approaches the larva returns to the bud and pupates near the tip from which the end of the pupa often slightly protrudes. Some infested buds show only slight development; others burst out into practically full leaf development before dying. Occasionally adventitious buds develop from the base of the original bud. Buds from the second to sixth from the soil are commonly attacked, but occasionally a bud near the top of the cane may be infested. Apparently the whole damage done by the insect is the killing of the buds. Massee (1) states that newly hatched larvae feeding within the receptacles of the maturing fruit cause little or no damage. The writers have found this to be the case.

Life-history.—The overwintering larvae emerge from their winter quarters near the latter part of April or early in May and at once begin boring into the buds which are beginning to show some green at this time.

Massee (1) states the overwintering hibernacula may be situated on the canes or in the soil and rubbish about the bases of the canes. The writers were unable to find hibernacula, and believe these are located only in the surface soil or rubbish. Overwintering canes were removed early in the spring and examined in the laboratory for hibernacula. A barrier was constructed about the place from which the canes were cut off and on May 9 the first larvae were seen crawling about on the soil and upon the short stumps of the canes within the barrier. Larvae were seen elsewhere in the plantation at this time. Only twenty-four larvae were recovered from within the eighteen square feet of barrier between May 9 and May 16. Larvae also appeared on the canes below tanglefoot barriers which were placed as near as possible to the base of the canes.

On June 3, 1939, the first larvae were seen in a reversed position within the buds, that is, with the head facing the entrance hole. Portions of a web seemed to be formed in some cases. Three days later pupae were found. These were light brown in color and about one-quarter of an inch in length. Later, the color darkens to a deep brown. Moths emerged in the laboratory on June 19 and on the 20th were found in the field. The pupa stage is, therefore, of two weeks duration. The moths have a wing expansion of about five-eighths of an inch, are black in color, with small yellow spots on the wings. In the field they appear most numerous late in the afternoon making short "dancing" flights about the lower parts of the cane before coming to rest on the undersides of the leaves.

European workers state the eggs are laid on the stamens, the new larvae developing within the receptacles of the ripening fruit without injury to the fruit. The writers caged moths over raspberry blossoms but did not locate eggs or larvae later. On July 28 new larvae were found feeding on the receptacles of the fruit elsewhere in the plantation. On such fruit a thin brownish inconspicuous trail could often be seen leading from a point near the sepals into the base of the receptacle. Towards the end of July the larvae disappeared from the canes. A barrier of plaster of paris had been constructed on the surface of the soil about the bases of some canes to catch the larvae on their way into winter quarters. Although a number of *Byturus* larvae were taken only one *Lampronia* larva was secured, namely on August 3.

Control Measures Attempted.—In the early spring of 1939 a dormant application consisting of 2% lubricating oil emulsion and 4% of Dinitro-o-cyclohexylphenol was applied to two rows. When emerging larvae were first seen crawling, various nicotines used alone and in combination with 2% white oil emulsion were applied to other rows. Nicotine sulphate and nicotine alkaloid were used at the rate of one quart to one hundred gallons of water and the fixed nicotine at the rate of ten pounds to one hundred gallons. The results were as follows:

			canes examined	*buds counted*	*percentage infested*
Dinitro-oil	ground treatment only	dormant stage	50	852	.9
Dinitro-oil	ground and cane treatment	"	50	874	1.8

Note: *Specifications of oil used*

Specific Gravity at 20 deg. C. .... 26 A.P.I.
Flash point (open cup) ....400 deg. F.
Viscosity at 100 deg. F. ....210 sec. Say.
Volatility (loss at 100 deg.-105 deg. C. after four hours) 0.7%
Unsulphonatable residue 78.0%
Iodine value (Hanus) 35

			Canes examined	*Buds counted*	*Percentage infested*
Fixed nicotine	ground and cane treatement	early green tip	50	863	3.8
Fixed nicotine & white oil	"	"	50	747	4.1
Nicotine sulphate	"	"	50	793	2.5
Nicotine sulphate and white oil	"	"	50	842	3.4
Nicotine alkaloid	"	"	50	817	3.7
Nicotine alkaloid and white oil	"	"	50	810	5.3
Check			50	888	7.1

These results indicate that the dinitro oil spray applied to the soil and base of the canes in the dormant stage was the most effective control. Applied to the soil and canes together the treatment appears less effective which is disconcerting. The nicotines in combination with the white oil emulsions show less control in every case than when used alone. Nicotine sulphate, used alone, gave somewhat better results than either fixed or free nicotine which were about equal. The untreated plot shows a heavier infestation than the treated plots.

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BIOLOGICAL CONTROL OF INSECT PESTS IN CANADA WITH SPECIAL REFERENCE TO THE CONTROL OF THE EUROPEAN SPRUCE SAWFLY *GILPINIA POLYTOMA* HTG.

By A. B. BAIRD

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Just ten years ago the Dominion Department of Agriculture completed the purchase of property in Belleville, Ont., and established the Dominion Parasite Laboratory, thus recognizing in a permanent way the possibilities of biological control of insects as a part of the important economic service being rendered by the Division of Entomology to the people of Canada. Many changes have been made since 1929 and in addition to the original twenty room house modified for general office, laboratory and museum work, the property now includes a four compartment greenhouse, and a modern laboratory of concrete construction, with thirty rooms completely conditioned as to temperature and humidity, airconditioned dressing rooms, cold storage rooms, machine shop, packing and storage rooms, and other essential equipment. In the ten-year period nearly five hundred million parasites have gone out from the laboratory—these attacking a wide variety of insect pests in all parts of the Dominion. A few have gone to the United States, and some to far distant points in England, France, Holland, Argentina and Palestine.

At the time the Department decided upon the establishment of this laboratory, the cases of known value of the biological method of controlling insect pests in Canada were very few and those making the decision were influenced largely by successful work elsewhere, coupled with the fact that the method was accepted as being sound in principle. Successful control

has now been accomplished in many cases and it is the purpose of this paper to review these, as well as to indicate briefly the progress being made with others.

The first and, perhaps, one of the most outstanding projects in this field in Canada was the introduction from England by Hewitt (1910-13) of the parasite *Mesoleius tenthredinis* Morley to aid in controlling the larch sawfly. Liberations were made in central Quebec, southern Manitoba and northern Michigan, and no serious infestations have since occurred in these areas. From Manitoba and Quebec, the parasite has been collected and distributed in New Brunswick, Nova Scotia, northern Quebec, southern Ontario and British Columbia. It is at the present time being collected in southern New Brunswick for further distribution. Every place where it has been released under suitable conditions, control of the pest has been rapidly realized.

Between the years 1912 and 1916 parasites of the brown-tail moth (*Nygmia phaeorrhoea* Don.) were obtained by collection in New England and released in Nova Scotia, New Brunswick and Quebec. Two species of these at least became established, *Apanteles lacteicolor* Vier. and *Compsilura concinnata* Meig. and in Nova Scotia they probably played an important part in the elimination of this pest. The chief value of the introduction, however, lies in the establishment of *Compsilura* on several native insects from which it later spread to the satin moth and became an important factor in its control. The satin moth (*Stilpnotia salicis* L.), a European pest, discovered on both the east and west coasts of this continent in 1920, has been very effectively checked by European parasites, including *Compsilura concinnata* and *Eupteromalus nidulans* Foerst., parasites also of the brown tail moth, and *Apanteles solitarius* Ratz., a specific satin moth parasite. This last named species was first released in New England in 1927 and in Canada in 1933. Its increase and spread have been phenomenal wherever released and the trees covered with thousands of its white cocoons in the areas previously swarming with caterpillars furnish undisputed evidence of its value.

The oyster-shell scale (*Lepidosaphes ulmi* L.), an insect of rather minor importance in Eastern Canada, was considered a serious pest in the Okanagan Valley of British Columbia, where it propagated freely on a number of species of native shrubs and trees, making its control on fruit trees difficult. An investigation by Tothill (1916) showed an important natural enemy lacking and the transfer of the predaceous mite, *Hemisarcoptes malus* Sch. from New Brunswick, proved of great value in reducing the scale and thus assisting the fruit growers of the Okanagan Valley. The woolly aphis parasite, *Aphelinus mali* Hald., transferred from Belleville, Ont., in 1929, has likewise reduced its host and proven of tremendous value to the Okanagan growers.

Allotropa utilis Mues., a parasite of the apple mealy bug in Nova Scotia, and released in the Kootenay Valley of British Columbia in 1938 gives promise of equally valuable results.

The European lecanium scale (*Lecanium coryli* Ledgr., had become a serious shade tree pest in Vancouver, B.C., making necessary a spraying programme which cost several thousand dollars and spreading annually to adjacent municipalities. In 1928 and 1929 the chalcid parasite *Blastothrix sericea* Dalm., was obtained from England and from a few hundred

individuals released, it became established and spread so rapidly that by 1932 the host was reduced to such an extent it was not possible to make collections. The infestation has continued very light since that time .

Prior to 1929 the Oriental fruit moth (*Laspeyresia molesta* Busck.) threatened the peach growing industry in southern Ontario so seriously that orchards were being pulled out and destroyed. The parasite *Macrocentrus ancylivorus* Rohwer, obtained by collection in New Jersey and released for the first time in 1929, supplemented by releases each year in new areas for distribution purposes has proven even more successful than in its New Jersey home, and reduced the fruit moth to a pest of minor importance for the Ontario growers.

The work done on propagation and distribution of the greenhouse whitefly parasite, *Encarsia formosa* Gahan, has been referred to on several occasions. Breeding stock of this species has been maintained at Belleville since 1932, and its use has increased annually as more growers have become acquainted with its value as a control factor. During 1938 upwards of one million individuals were sent out and the distribution of this parasite is worth thousands of dollars to the greenhouse industry. Equally good results have been obtained during the past two years in controlling the common greenhouse mealy bug *Pseudococcus citri* Risso, by the use of the parasites *Leptomastix dactylopii* How., and *Leptomastidae abnormis* Gir. Parasites of another common greenhouse mealy bug, *Pseudococcus maritimus* Ehrh., are also being propagated at the laboratory this year and will be available for distribution to growers on the same basis as the other parasites of greenhouse insects. Aphids have been controlled by parasites in the laboratory greenhouse for the past four years and the efficacy of their use commercially has also been demonstrated in commercial greenhouses, so the service can be made available when desired.

The pine sawfly, *Diprion simile* Hartig., introduced from Europe, has been held in control in Ontario chiefly by the European parasite, *Monodontomerus dentipes* (Boh.), presumably introduced with its host. An infestation of the sawfly discovered later in the district around Montreal, P.Q., was increasing rapidly and the parasite was absent. The situation was remedied by transfer of a colony of *M. dentipes* from Ontario to Montreal. An incipient outbreak of another European pine sawfly, *Diprion frutetorum* Fabr., in Ontario was checked by the timely liberation of the cocoon parasite, *Microplectron fuscipennis* Zett.

For a number of projects we can report satisfactory progress but some years may be required to achieve effective control. The European corn borer parasites, *Macrocentrus gifuensis* Ashm., *Chelonus annulipes* Wesm., and *Inareolata punctoria* Rom., are now established in the Belleville Ont., district and using recovered material as breeding stock, liberations are being made in other areas. Establishment of wheat-stem sawfly parasites in Western Canada received a serious setback with the severe drought conditions and grasshopper outbreaks destroying practically all crops in the areas where early releases were made. Small colonies of *Collyria calcitrator* Grav., *Pleurotropis benefica* Gahan and *Heterospilus cephi* Rohwer have been released in other areas and initial establishment of the first two has been indicated by recoveries. These parasites are also established in Ontario, the first from liberation of European material and the others presumably as a result of natural spread from the United States.

One of the European parasites, *Glypta haesitator* Grav., released against the pea moth, has already been recovered in considerable numbers, although the project has been under way only three years. This, with other species being released, is an important control factor in England. The codling moth parasite, *Ascogaster carpocapsae* Vier., is now established in the Okanagan Valley of British Columbia, as a result of the release of material propagated at the Belleville Laboratory. Additional parasites of this insect have been located in France and collection of material for Canada is in progress at the present time. The European earwig parasite, *Digonochaeta setipennis* Fln., has been successfully propagated at Victoria, B.C., and is now established in the lower end of Vancouver Island. Releases of this parasite have also been made in the Lower Fraser Valley of British Columbia, and in the recently discovered area infested by the earwig at Ayton, Ont. Several parasites of the larch casebearer, obtained from England and Central Europe have been released and three species have already been recovered in the Belleville area, viz., *Dicladocerus westwoodi* Steph., *Angitia nana* Grav., and *Microdus pumilus* Ratz. Pine shoot moth parasites imported from Europe are established at a number of points and include *Cremastus interruptor* Grav. and *Orgilus obscurator* Nees., two species of considerable importance. A number of predators of the balsam woolly aphis (*Dreyfusia piceae* Ratz.) have been obtained from England and one species, *Leucopis obscura* Hal., is well established and already present in fairly large numbers in the liberation areas in New Brunswick. Parasites of the holly leaf miner, obtained in England, have been relased in considerable numbers in the Victoria and Vancouver districts of British Columbia, and initial recoveries of one species were made at Victoria. Work with natural enemies of grasshoppers has been under way only two years but the investigations have already brought to light a wide range of insect parasites and predators operating in the different areas. An important parasite of grasshoppers in Argentina has been obtained, and a sufficient number propagated at the Belleville Laboratory for two small experimental field liberations in the Belleville area.

The largest and most important project in biological control yet undertaken in Canada is concerned with the European spruce sawfly, *Gilpinia polytoma* Htg. Incepted in 1932, immediately after the pest was identified as of foreign origin, this project is being carried out through a most comprehensive organization, under direction of the Dominion Entomologist, including, in addition to the Dominion Division of Entomology, a large group of workers in Europe directed by officers of Farnham House Laboratory; the Forest Protection Services of the provinces of Nova Scotia, New Brunswick, Quebec, and Ontario; the Forest Protection Associations in the province of Quebec; the Quebec Forest Industries, Limited; the Pulp and Paper Associations, and the individual lumber companies and land owners in the four provinces affected. The work is also being carried out in co-operation with the United States Bureau of Entomology and Plant Quarantine, and with the Forest Service of the State of Maine, and full advantage is being taken of their advice and assistance. The parasite material obtained in foreign countries is all being handled at the Belleville Laboratory where special equipment was provided to make this possible, and more than thirty million sawfly cocoons have been received and reared for emergence of parasites. A total of 454,791,000 parasites, including eighteen species, has been released to date, the majority of these being of the species *Microplectron fuscipennis* Zett., a cocoon parasite which has been propagated at the laboratory during the past three years. Large scale

propagation and distribution of this parasite was decided upon after initial liberations had demonstrated the ability of the species to attack the sawfly and build up under forest conditions in a number of different areas. In the summer of 1937 cocoons collected near a point of release in the Matapedia Valley, P.Q. were heavily attacked by *Microplectron*, some collections showing as high as 60 per cent of the sound cocoons parasitized. The following year the parasitism was so widespread that collection of cocoons for parasite propagation work had to be moved elsewhere. In the late fall of 1937 collections of cocoons made near liberation points along the St. Lawrence River in the vicinity of St. Roch des Aulnaies showed parasitism of 50 to 70 per cent, and during the summer of 1938 this condition became quite general as in the Matapedia Valley. At Parke Reserve where the first liberations of this parasite were made the same condition was reached during 1938, the number of generations annually being reduced by reason of the short season at this high altitude. In New Brunswick collections made during the present season by the Forest Insects Unit show parasitism ranging up to 75 per cent with an average of around 40 per cent from collections over a fairly large area. In a recent survey the parasite was found in areas with all degrees of infestation from very light to very heavy. Parasitized cocoons were also found to a depth of 3 inches in moss as well as in debris on the surface, and the number of sawflies destroyed must be a very important factor in reducing the sawfly population. Another parasite, *Exenterus sp.*, which oviposits on the full grown feeding larvae on the trees has become established very readily wherever it has been released and is rapidly becoming an important control factor. It is sufficiently abundant in two areas to make collection for redistribution economically possible. At the Parke Reserve, P.Q. experimental area two additional species of parasites are established in small numbers and appear to be increasing satisfactorily.

Large areas of infested forest still remain to be treated and other species of parasites may prove of greater value than those already established so the work must continue unceasingly for some years. The outlook is, however, promising and there is now some hope that our vast northern spruce forests may be spared the fate of the eastern larch forests in the last century.

Evaluation of the results of parasite distribution or of the part played by parasites in the control of insect pests is a difficult matter and no method capable of general application has yet been devised. The examination or rearing of sample collections is most frequently used as a basis for the calculation of percentage parasitism, and this is taken to indicate the degree of control effected. The conclusions arrived at in this way are sometimes very misleading and in the present paper reference to percentage parasitism has been omitted except in cases where it is used to indicate the initial establishment or rapid increase in population of an introduced species. The establisment and maintenance of a parasite as indicated from samples is evidence that the normal population increase ofthe host is being affected in some degree, the extent being influenced by the environment as well as the parasite. The host population necessary to cause injury or commercial loss varies with each insect and in many cases with the different species of plant or animal attacked. A reduction in injury caused by the host that can be attributed in whole or in part to the action of the parasite is at present the only criterion we have of its value. Careful and exhaustive research on a wide variety of insects over a period of years is essential in the development of a more satisfactory standard of measurement.

The biological method of control is not a cure-all for all insect troubles and it should be our endeavour to concentrate largely on those pests which research and experience indicate can be most satisfactorily handled in this way. In some cases, particularly our forest insect problems, we have recourse to no other method at present, and in our efforts to conserve natural resources this should be given very special attention. In many fields insect parasites can be used along with other methods of control and it should be emphasized that they are in themselves positively harmless.

Biological control has the added value of increasing with each generation of the parasite and its effect increases and spreads naturally, and is maintained over an indefinite period. It is safe, effective and economical and in these times of stress may well be further developed as one of the first lines of defense against our insect foes.

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AN EXCHANGE OF GRASSHOPPER PARASITES BETWEEN ARGENTINA AND CANADA WITH NOTES ON PARASITISM OF NATIVE GRASSHOPPERS

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Introduction.—In the autumn of 1936 Mr. C. A. Lizer Y. Trelles of the Argentina Department of Agriculture expressed in correspondence with Dr. Arthur Gibson, the Dominion Entomologist, a desire to arrange an exchange of grasshopper parasites with Canada. The species of particular interest to Argentina were *Systoechus vulgaris* Loew, a beefly whose larvae are predaceous on grasshopper eggs and *Sarcophaga kellyi* Ald. the larvae of which are parasitic in late nymphal and adult grasshoppers. Both species have frequently been recorded as enemies of grasshoppers in Canadian reports. By way of investigating the possibility of securing quantities of these two species for exchange, officers* in charge of Dominion Entomological Laboratories in Western Canada submitted memoranda reviewing the occurrence to date of these and other parasitic, predaceous and pathogenic organisms in their territories. These memoranda included an interesting list of birds, mammals, disease organisms and insects. Of these, insects appear to have been the most important although disease has on occasion been a potent mortality factor. These records will be treated briefly later in this paper.

During 1937 an effort was made by officers in charge of grasshopper work in the West to collect any insects that appeared to be parasitic or predaceous on grasshoppers. As a result, many dipterous and coleopterous larvae and pupae were collected during the grasshopper egg surveys in Alberta, Saskatchewan, and Manitoba, and many dipterous larvae were recovered from caged grasshoppers at Kamloops, B.C.

Material was received from the several western points as follows:

Place	*Systoechus vulgaris*	*Sarcophaga spp.*	*Others*
Brandon	335		
Estevan	321	6	47
Saskatoon	264	33	
Lethbridge	38	9	32
Kamloops		43	16
Total	958	91	95

With the exception of the material from Kamloops, all was field collected and apart from *S. vulgaris* Loew., its host relationship was not known. In order to separate any *Sarcophaga kellyi* Ald. that might be present all the unknown dipterous larvae and pupae were divided into groups on detectable differences. Material from the several points was distributed to different groups as follows:

Source	Groups A.	B.	C.	D.	E.	F.	G.	H.	I.
Estevan				1		4			
Saskatoon	5	1		2		22			
Lethbrige				3	1	4			
Kamloops			1	3	32	7	8	1	6
Total	5	1	1	9	33	37	8	1	6

*E. R. Buckell, G. J. Spencer, H. L. Seamans, K. M. King, R. D. Bird.

Only two groups "E" and "F" were sufficiently well represented to supply specimens for shipment and still provide a few for rearing and identification. It seemed probable that one of these two (particularly "F") would prove to be *S. kellyi* Ald. Group "F", however, turned out to be *Sarcophaga hunteri* Hough and group "E" was found to be *Sarcophaga opifera* Coq. No adults resulted from groups "A", "B", and "C"; group "D" produced adults of *Sarcophaga reversa* Ald., *S. coloradensis* Ald., *S. aculeata* Ald., and *S. atlanis* Ald. Four females of this group could not be placed to species. The larvae in group "G" belonged, quite definitely, to a different family and finally proved to be those of the nemestrinid *Parasymmictus clausus* O.S. The single specimen in group "H" was a tachinid of the genus *Hemithrixion* or *Acemya* although no adult was reared. Group "I" contained *Hylemya nidicola* Ald. Mr. G. E. Shewell, Ottawa, very kindly identified the specimens of *H. nidicola* Ald. and verified determinations of the sarcophagids submitted.

Parasites for Argentina.—As a result of the 1937 season's collecting, a quantity of *Systoechus vulgaris* Loew, *Sarcophaga hunteri* Hough, and *Sarcophaga opifera* Coq. were forwarded to Argentina during the winter of 1937-38. All shipments were by air express and addressed to Dr. A. A. Ogloblin, chief of the Department of Locust Investigations.

The first shipment, consisting of 30 *S. hunteri* Hough, 25 *S. opifera* Coq. and 150 *Systoechus vulgaris* Loew, left Belleville for Buenos Aires by air express on December 2, 1937. It arrived at its destination in good condition on December 8, just six days after leaving Belleville. A second shipment containing 620 larvae of *Systoechus vulgaris* Loew left Belleville on January 6, 1938 and reached its destination on January 16 with only 3.2 per cent mortality. Further shipments of parasites obtained from field collected and laboratory propagated material were sent during 1939. One shipment forwarded on July 13 contained 200 *Systoechus vulgaris* Loew and 16 *Sarcophaga hunteri* Hough. On October 18, 20 *Sarcophaga aculeata* Ald., 10 *Sarcophaga atlanis* Ald., and 16 *Sarcophaga hunteri* Hough were shipped.

Regarding the original shipment of 1937, Dr. Ogloblin later reported that adults of both the sarcophagid species had been obtained and were living well in cages. *S. hunteri* Hough had successfully developed in three grasshopper species representing the genera *Trigonophymus, Dichroplus* and *Scylline.* This species had also parasitized *Schistocerea paranensis* Burm. but no mature larvae had resulted. No success was had with *S. opifera* Coq., and the beefly larvae were not reacting well to handling.

Parasites to Canada.—Canada has now received several shipments of parasites from Argentina. The first shipment of 295 *Sarcophaga caridei* Brethes larvae was despatched from Buenos Aires on March 31, 1938 and reached Belleville seven days later with 182 larvae living, 20 larvae dead and 93 puparia. Further stock of this same parasite was received in 1939. One lot, received on June 19, consisted of 45 *S. caridei* Breth. larvae and pupae. On August 20 an additional 31 sarcophagid larvae were received An undetermined sarcophagid species was included in the last shipment. Only females of this species were obtained, however, and experimental propagation was not possible.

Propagation of Sarcophaga caridei Brethes.—Before commencing propagation of *S. caridei* Brethes it was necessary to have a supply of host material on hand. Efforts to propagate grasshoppers in the laboratory

during the winter of 1937-38 had not been successful and only a few individuals of *Camnula pellucida* Scud. were on hand when the parasites arrived from Argentina. It was thus necessary to delay emergence of the Argentina parasites until grasshoppers were available in the field. Small numbers of larvae and puparia were removed from storage (38 deg.-42 deg. F) and placed in incubation (73 deg.-75 deg. F) during the period May 12-July 15. The first shipment eventually produced 72 male and 51 female *S. caridei* Brethes adults.

Fortunately, we had little difficulty with mating in cotton covered cages at 72 deg. - 74 deg. F. and were later successful in securing larvipositions on grasshoppers presented to the flies. Following a short gestation period, during which the first instar larvae develop within the uterus, the females showed little hesitation in darting at the grasshoppers to deposit their young. The larvae, ejected with a small amount of fluid, quickly crawled to some membraneous part of the host's body, pierced it with their mouth parts and drew themselves in. In some instances this was done very rapidly; in others the larvae had to work strenuously to gain entrance. Once inside, the larva develops through three larval instars and emerges to pupate. The host is killed as a result. Larvae and pupae resulting from the first season's work were placed in storage for hibernation, but only two males emerged from these in the spring of 1939 and it was necessary to secure additional material from Argentina. From the 45 larvae and pupae received on June 19, 17 male and 13 female. *S. caridei* Brethes adults were secured. With these as stock the season's effort was directed particularly towards a more detailed record of the parasite's biology and its ability to develop in the various grasshopper species available for test purposes. The suitability of the various hosts was especially important from the standpoint of its usefulness against the pest species. It was also desirable to know what species might serve as favourable hosts for its laboratory propagation.

Our present findings indicate that three generations are possible in the field and that at least five species of grasshoppers may serve as hosts. Females mate soon after emergence. There is a gestation period of 7-10 days, a larval period of 5-7 days, and a pupal period of 13-16 days. Including the gestation period, a complete life cycle requires approximately 30 days at 74 deg. F. At this same temperature longevity of mated females under laboratory conditions ranges from 30 - 69 days. The average number of larvae deposited per female is 75 and the maximum number of larvae secured to date from one female is 104.

Camnula pellucida Scud. has so far proven to be the most favourable host. Over seventy per cent of the larvae deposited on this host have matured and approximately sixty per cent have produced adult flies. *Melanoplus mexicanus* Saus., *M. femur-rubrum* De. G. and *Orphulella speciosa* Scud. all proved to be satisfactory hosts. *M. bivittatus* Say has so far not proved very satisfactory although the tests on this species have been somewhat limited. One adult was secured with *Gryllus assimilis* Fab. as host but this species did not prove suitable for laboratory propagation. *S. caridei* Brethes larvae did not mature in *Dissosteira carolina* L.

The first releases of *S. caridei* Brethes in Canada were made on September 11, 1939. These releases consisted of 24 mated females at Brighton, Ontario, and 24 mated females at Chatterton, Ontario.

The vigour of attack of *S. caridei* Brethes and its ability to propagate on a number of our native grasshoppers, particularly three of the pest species, would seem to mark it as a valuable addition to our parasite fauna.

Native Grasshopper Parasites.—Memoranda submitted by the various officers in Western Canada, previously referred to, indicate that the egg predator *Systoechus vulgaris* Loew is the species of chief importance in the Prairie Provinces whereas the sarcophagids have been most prominent in British Columbia. A list of predators, parasites and disease organisms included in these memoranda is as follows:

Predators.—Mammals: coyote, ground squirrels, skunk.
Birds: crow, Franklin's gull, Brewers blackbird, American sparrow, hawk, mountain blue bird, chipping sparrow, Clarke's nutcracker, Lewis woodpecker, Western meadowlark.
Insects: *Systoechus vulgaris* Loew, *Percosia obesa* Say, *Epicauta subgratera, Lytta sphaericollis* Say, *Macrobasis subglabra* Fall., *Psilocephala munda* Loew, *Oxytropis campestris* and several species of asilids.

Parasites.—*Scelio calopteni* Riley, *Scelio* sp., *Sparaison* sp., *Xyalophora quinquelineata* Say, *Sarcophaga kellyi* Ald., *S. hunteri* Hough, *S. rapax* Wlk., *S. opifera* Coq., *S. mison* var *sarracenioides* Ald., *S. misera* var *harpax* Pandelle, *S. aculeata* Ald., *S. sinuata* Meig. *Sarcophaga spp.*, an undetermined tachinid and mermithid worms.

Disease Organisms.—*Empusa grylli*
? *Coccobacillus acridiorum*
? Polyhedral disease

A secondary parasite, *Aphaereta muscae* Aslm., was reared from *S. rapax* Wlk. puparia in British Columbia as well as an undetermined chalcid. The presence of secondary parasites was recognized in Alberta although no species were mentioned.

Parasites were credited with bringing grasshopper outbreaks under control in British Columbia on two occasions: at Chilcoten in 1930 and at Lytton in 1931.

Sarcophaga kellyi Ald. was the only sarcophagid named as having been definitely reared from grasshoppers in the Prairie Provinces. This species was not recovered from any of the collections made in the West in 1938 or 1939 although the writer reared this species from grasshoppers collected at Swift Current, Saskatchewan in 1934.

The names of a number of species can now be added to that of *S. kellyi* Ald. as having been reared from the Western grasshoppers. These definite records of parasitism have resulted from collections of grasshoppers made in Southern Manitoba in 1938 and 1939 by officers of the Dominion Entomological Laboratory, Brandon, and reared at Belleville. Additional field collected parasite material obtained in 1938 by Divisional Officers in Saskatchewan has also included a number of these same species although definite host associations could not of course have been made from field collected material .The additional species are as follows: *Sarcophaga reversa* Ald., *S. atlanis* Ald., *S. hunteri* Hough, *Hemithrixion* sp. *Acemya tibialis* Coq.; one nemestrinid, probably *Parasymmictus clausus* O.S.; one dipterous species undetermined (probably undescribed). The round worm *Agamermis decaudata* has also frequently been taken as a parasite.

The two secondary parasites *Brachymeria coloradensis* Cress and *Perilampus hyalinus* Say. have occurred in some numbers.

From collections of grasshoppers made at Chatterton and Brighton, Ontario, in 1938 and 1939 the following parasites have been reared: *Sarcophaga reversa* Ald., *S. aculeata* Ald., *S. hunteri* Hough, *S. atlanis* Ald.; *Acemya tibialis* Coq. *Ceracia* sp.; mermithid worms. The secondaries, *B. coloradensis* Cress and *P. hyalinus* Say were also present in the Ontario collections.

Sarcophaga reversa Ald. was most abundant in the early collections and the other three sarcophagids more abundant in the middle and late season. The South American *S. caridei* Breth, is very similar to the native *S. aculeata* Ald.

Notes on habits of some of the parasites encountered.—Attempts were made to propagate several species of parasites in order to obtain information on their life history, to secure immature stages for study, and if possible to obtain larvae and pupae for shipment to Argentina.

From the observations made, it is believed that *S. reversa* Ald. and *S. aculeata* Ald. attack the grasshoppers in flight and deposit their larvae in much the same manner as *S. caridei* Brethes. The method of attack of *S. hunteri* Hough and *S. atlanis* Ald. in the field is uncertain. In cages both species stalk their victim and neither has been observed to make quick dashes at its host. *S. atlanis* Ald. deposits free larvae whereas *S. hunteri* Hough deposits its much flattened larvae enclosed in the chorion. When an opportunity presents itself, *S. hunteri* Hough carefully places its egg between the abnominal segments of the grasshopper. The larva soon leaves the chorion and enters the body of the host. *S. atlanis* Ald. has not been observed to deposit its larvae but when these are removed from gravid females and placed on a grasshopper they very quickly seek a membranous area and enter.

Of particular interest is a small undetermined dipterous fly reared from *M. bivittatus* Say collected at Arnaud, Manitoba, in 1938. Dr. Howard Curran, to whom specimens were submitted through the headquarters of the Division of Entomology, at Ottawa, reports that the species and genus is undoubtedly new. Our observations indicate that this fly has a very strange method of placing its eggs in its host. It is as follows: The female stealthily approaches a grasshopper and punctures the victim's body with its piercing mouth parts. It then places the tip of the abdomen against this opening and inserts its eggs. That this actually occurs is borne out by the fact that the ovipositor is not fitted for piercing and that a grasshopper attacked in this manner was found to contain eggs of this species. We are awaiting with interest the final determination and taxonomic placing of this fly.

A few interesting observations have also been made on the secondary parasite *P. hyalinus* Say. It is well known that the planidia or first instar larvae of *Perilampus* are to be found in the bodies of insects likely to be selected by some primary parasite. If a *Perilampus* planidium and a dipterous parasite be present in a host, the planidium enters the dipterous larva and remains undeveloped until the larva has formed a puparium. It then leaves the larva and takes up a position between the larva and the puparium where it commences to feed as an ecto-parasite. It passes through its larval stages, pupates and finally emerges as an adult from the host pup-

arium. There has been some speculation on the manner in which the *Perilampus* enters the host of the primary parasite. Our own observations have shown that *P. hyalinus* Say, deposits its eggs on grass blades. At 74 deg. F. these hatch in about six days and the young planidia wander slowly over the blade, frequently standing erect on their caudal setae. Eggs and planidia swallowed by grasshoppers did not survive their experience, but two planidia were observed to puncture the fleshy tarsal pads and enter in this way. One female *Perilampus* was observed to lay approximately 600 eggs during an eight day period.

BIOLOGICAL CONTROL OF GREENHOUSE INSECT PESTS

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The problem of controlling greenhouse insects is complicated by several factors that are not found in any other field of insect control. Both tropical and indigenous insects are present. Favourable conditions for plant growth also make possible rapid development and increase of the pests, and many generations may develop during the continuous growing season that is provided by artificial heat. Vegetables and flowers grown under glass are usually more tender and, therefore, more subject both to insect attack and injury, and to insecticide injury where chemicals must be used to control the pests. The problem, however, is simplified to some extent by the fact that control measures are usually more effective and more economical in relation to the cost of the crop, in such enclosed spaces.

The injury to plants and the resulting loss to growers may be reduced by cultural practices, insecticides and fumigants, or by the use of natural enemies. The use of natural enemies in greenhouses is a comparatively recent development but results have shown that some of the most important insect pests can be controlled by this method.

The first record of the successful use of parasites was reported in 1927, from the Cheshunt Experiment Station in England (Speyer, 1927), where the chalcid parasite, *Encarsia formosa* Gahan, was used to control the greenhouse whitefly, *Trialeurodes vaporariorum* Westw. The value of this parasite was recognized immediately and distribution to most parts of the British Empire followed. Dr. Speyer also made a survey of the natural enemies of greenhouse pests and published a list (Speyer, 1926). A few years later (Speyer, 1933) the tomato moth parasites, *Comedo opaculus* Thoms. and *Pimpla instigator* L., were investigated and an attempt was made to develop a method for propagating these parasites.

The control of mealy bugs by means of the predator, *Cryptolaemus montrouzieri* Muls., has been under investigation at the Agricultural Experiment Sub-station, Waltham Mass. (Whitcomb, 1934-5-6-7-8). The general conclusion from these investigations is that mealy bugs can be controlled in greenhouses by the use of *Cryptolaemus* if the predators are properly manipulated and if the temperature is at least 70 deg. F. If the temperature is below 70 deg. F., the biotic potential of the predator is lower than that of the host insects, and control cannot be accomplished without assistance from some other source.

C. C. Compton, Urbana, Ill., has investigated a number of parasites of greenhouse pests (Compton, 1938). These and other natural enemies that have been reported are listed in the following table:

GREENHOUSE PESTS AND NATURAL ENEMIES

Pest: Family	Pest: Species	Natural Enemy: Family	Natural Enemy: Species	Observer	
Homoptera Aleyrodidae	*Trialeurodes vaporariorum* Westw.	Aphelinidae	*Encarsia formosa* Gahan	Speyer	1927
			Encarsia partenopea Masi	Hodson & Beaumont	1929
			Encarsia versicolor Gir.	McDaniel	1931
Aphididae	*Myzus persicae* Sulz. and other aphids	Aphelinidae	*Aphelinus jucundus* Gahan	McLeod	1937
			Aphelinus marlatti Ashm.	McLeod	1937
		Braconidae	*Aphidius phorodontis* Ashm.	McLeod	1936
			Ephedrus nitidus Gahan	McLeod	1937
Coccidae	*Pseudococcus citri* Risso	Encyrtidae	*Leptomastidea abnormis* Gir.	Compton	1938
			Leptomastix dactylopii How.	McLeod unpublished	
		Coccinellidae	*Cryptolaemus montrouzieri* Muls.	Whitcomb	1934-35-36-37-38
	Phenacoccus gossypii T. and Ckll.	"	" "	"	" "
		Encyrtidae	*Leptomastidea abnormis* Gir.	Heming	1936
Lepidoptera (Pyralidae)	*Phylctaenia rubigalis* Guene	Braconidae	*Microgaster spagages* Gahan	Compton	1938
Noctuidae	*Polia oleraceae* L.	Aphelinidae	*Comedo opaculus* Thoms.	Speyer	1933
		Ichneumonidae	*Pimpla instigator* L.	Speyer	1933
Diptera (Mycetophelidae	*Acaria* sp. (mushroom fly)	Braconidae	*Praon* sp.	Speyer	1933
Acarina	*Tetranychus telarius* L.	Cecidomyidae	*Therodiplosis persicae* Kieff.	Speyer	1926
		Acarina	Gamasid (Undetermined)	Speyer	1926
		Coccinellidae	*Stethorus punctum* Lec.	McLeod unpublished	
Oniscoida	*Cylisticus convexus*	Malacodermidae	*Telephorus fuscus* L.	Speyer	1926
Unclassified					
Feeding on insects in cucumber houses		Staphylinidae	*Ocypus morio* Gr.	Speyer	1926
			Ocypus olens Mull.	Speyer	1926
			Leistotrophus nebulosus F.	Speyer	1926
Insects in mushroom beds		Empididae	*Tachydronia flavicornis* Mg.	Speyer	1926
Insects on chrysanthemums		Reduviidae	*Nabis lativentris* Boh.	Speyer	1926
Lepidoptera on tomato		Ichneumonidae	*Pimpla instigator* F.	Speyer	1926
Various pests		Amphibia	*Bufo vulgaris* L.	Speyer	1926
			Rona temporaria L.	Speyer	1926
Various Lepidoptera		Trichogrammidae	*Trichogramma minutum* Riley	Compton	1938

This list represents only a small proportion of the natural enemies that are available for use against greenhouse pests. An investigation by the writer has shown that thirty-five species of natural enemies have been recorded from the common mealy bug, *Pseudococcus citri* Risso. Russell (1912) lists several internal parasites of thrips. Ball, Reeves, et al (1935) have published a list of the natural enemies of the greenhouse leaf tyer, *Phlyctaenia rubigalis* Guene. Other important greenhouse pests are known to have numerous natural enemies but their usefulness as control agents has not been studied.

Biological control of greenhouse insect pests was incepted in Canada in 1928 when a stock of *Encarsia formosa* Gahan was obtained by the Dominion Entomologist from England and released in a greenhouse at London, Ont. Technique for rearing and distributing the parasite under Canadian conditions was delayed until 1931 when a greenhouse was built at the Belleville Laboratory. The first shipments were sent to selected growers to test its efficiency. Enthusiastic reports were received from the initial releases and a demand developed for the parasites that has increased each year. The number of whitefly parasites that have been shipped to greenhouse men during the past five years is indicative of the value that is placed upon them as a practical and effective control of the whitefly.

Number of *Encarsia* shipped during the period 1935 to 1939:

1935	230,800
1936	326,160
1937	602,000
1938	845,000
1939	1,118,900

This parasite has been shipped to Newfoundland as well as to all provinces of the Dominion.

Officers of the Division have investigated the results of releases in commercial greenhouses and government institutions. These investigations have shown that definite control of the whitefly has followed the introduction of *Encarsia*. Further evidence of the value of the parasite is contained in numerous letters that have been received from growers. Some excerpts from these are given below.

Sevenoaks P.O., Victoria, B.C.—"Will you kindly send me some of the whitefly parasites as I find I have quite a lot of fly brought in on plants I bought. We had no whitefly last year, the parasite was very effective."

London, Ont.—"We note with great satisfaction that the infestation of whitefly is now almost nil—. We find the parasite method by far the best in the elimination of these pests."

Ladner, B.C.—"Last year they (the parasites) were again very helpful, our houses were clear of whitefly the whole time. We would not get rid of them by spraying no matter what we used. In fact, if we could not get this help from you, we would have to give up growing some of our specials."

Production methods have been developed that will insure a supply of the parasite throughout the year. Distribution problems and a suitable method of determining the number of parasites that are required to control the pest under varying greenhouse conditions have been solved (McLeod, 1938).

The biological control of aphids was undertaken in 1932 as a local problem. Plants grown in the laboratory greenhouse could not be treated with insecticides and it became essential to use other methods of control. The results have been most gratifying. All aphid infestations in our greenhouses during the past five years have been controlled by the use of parasites, without the assistance of sprays, dusts, or fumigants. Temperature is a most important factor, a mean of 65 deg. F. being sufficient to insure control by parasites.

Following requests from a number of greenhouse men for parasites of mealy bugs, Mr. A. B .Baird, officer in charge of the Dominion Parasite Laboratory, was instructed by Dr. Arthur Gibson, Dominion Entomologist, to investigate the possibility of utilizing parasites to control these pests under greenhouse conditions. The first shipment of parasites was received through Professor Harry S. Smith, from the Citrus Experiment Station, Riverside, California, in April, 1937. The parasite was *Leptomastix dactylopii* How., a species that had been imported into California from South America to assist in the control of the common mealy bug, *Pseudococcus citri* Risso. A few weeks previous to the arrival of these parasites (March, 1937), parasitized mealy bugs were found on a plant shipped to the laboratory from a greenhouse in London, Ont. The parasites that emerged from this material were later identified as *Leptomastidea abnormis* Gir. This species was discovered in Sicily in 1915 by Viereck and shipped to California for use against the common mealy bug. It has since been reported in greenhouses in Illinois and New York, and during the winter 1938-39 the writer found it in Ohio where it was doing effective work in the University greenhouses at Columbus.

Both species were retained and production was started in the autumn of 1937. During the following winter 42,425 *Leptomastidea* and 15,905 *Leptomastix* adults were shipped to greenhouses throughout Canada. Production of the latter species was increased in the winter of 1938-39 and 5,790 *Leptomastidea* and 84,585 *Leptomastix* were distributed.

In December, 1937, an experiment was conducted to determine the ability of adult *Leptomastidea* to withstand transportation during severe winter weather. A shipment was prepared and shipped from Belleville, Ont. to Agassiz, B.C. The shipment was made on December 23 by railway express, and reached Agassiz on December 27. It was reshipped December 28 and returned to Belleville on January 3, after a trip lasting eleven days and covering more than five thousand miles. The following day the parasites were examined and 49 per cent were alive and in good condition. The parasites were released in a parasite-free colony of mealy bugs and normal parasitism was secured. Further experiments have shown that the type of container in which the parasites are shipped is of minor importance. It is important, however, to provide insulation against extremes of temperature. It has also been found that food should be provided and either sugar or raisins have proven satisfactory.

The results obtained from the use of these parasites have been very satisfactory and many enthusiastic reports have been received from growers. Officers of the Division have checked the results of a number of liberations and have reported that the mealy bugs have been controlled where *P. citri* was the only species present. The following table shows the results of a definite check that was made only three months after the para-

sites had been released in a private conservatory. Mealy bug infested plants were selected at random and a count was made to determine the percentage parasitism.

Host Plant	Adult Mealy Bug	Parasitized	Unparasitized	*Leptomastix dactylopii*	*Leptomastidea abnormis*
Coleus	12	11	1	9	2
Begonia	18	16	2	7	9
Geranium	16	14	1	9	5
Total	46	41	5	25	15
Percentage		89.2	10.8	60.9	39.1

Although the results of many liberations were satisfactory, a number of unsatisfactory results were reported. These were investigated and revealed the fact that the mealy bug present was not *Pseudococcus citri* but *Pseudococcus maritimus* Ehrh. Later investigation indicated that this species is as widely distributed as *P. citri*. Both *Leptomastidea* and *Leptomastix* are specific on *P. citri* and for this reason it became necessary to obtain parasites of *P. maritimus*. Mr. C. P. Clausen and Dr. P. H. Timberlake made a detailed study of the parasites of *P. maritimus* in California (Clausen, 1924). This showed that *P. maritimus* is controlled in California by a number of native parasites. The writer can vouch for the scarcity of this mealy bug in California after collecting there for the recovery of parasites during the past summer. However, a few individuals of two species, *Zarhopalus corvinus* Girault and *Chrysoplatycerus splendens* How., were obtained and shipped to Belleville where they are being propagated at the present time. If these parasites are as efficient under greenhouse conditions as they appear to be in the field, the results should be most satisfactory.

In addition to the practical results that have been achieved to date, much information has been obtained that should be of considerable value in future investigations. It has been shown that greenhouse conditions provide certain advantages which should facilitate control by biological methods. Some of these factors are:

1. Greenhouse crops are under constant supervision; it is possible, therefore, to introduce parasites as soon as an insect pest is noted.

2. The extent of an infestation is definitely known and its boundaries are clearly defined.

3. Conditions of temperature and humidity are controlled. This is extremely important since it makes possible the definite determination of the rate of increase of both pests and parasites. Also, if parasites are present in a greenhouse, control of a pest can be secured through manipulation of the temperature.

4. Due to the limited area involved, the problem of dispersal is largely eliminated.

5. It is possible to use natural enemies in conjunction with other control measures, i. e., cyanide may be used to destroy adult whiteflies without

injuring the immature stages of the parasite, *Encarsia formosa* Gahan. A population of mealy bugs may be reduced by spraying infested plants with a stream of water under pressure, since the parasitized mealy bugs hide in the most accessible places.

The biological control investigations have shown some of the requirements that must be fulfilled if a natural enemy is to be successful under greenhouse conditions. Some of these requirements are:

1. Its biotic potential must be greater than that of the host insect. This does not necessarily mean that the individual reproductive rate of the natural enemy must be greater than that of the host. *Encarsia formosa* Gahan produces fewer eggs than its host, *Trialeurodes vaporariorum* Westw., but the sex ratio of the host is approximately 50 - 50, while that of the parasite is 100 per cent females, males not being required for reproduction.

2. The temperature range of the natural enemy should parallel that of its host. A natural enemy, to be successful, must control its host at the temperature at which the host plants are grown. If the host plant is grown at a temperature that favours the host insect and inhibits the natural enemy, control is obviously impossible. *Aphidius phorodontis* Ashm. will control *Myzius persicae* Sulz. at temperatures above 65 deg. F. Below that temperature the host insect increases more rapidly than the parasite. This example may also be used to illustrate the possibility of manipulating temperature to effect control.

3. The natural enemy must destroy all species of the host including physiological races. This applies particularly to mealy bugs and necessitates the accurate determination of the forms that are present when specific parasites are being used as control agents.

4. It must have the ability to maintain itself when the host population is low. *Encarsia* provides an excellent example of this ability; since mating is unnecessary, a population may develop from a single female. Another factor that favours this and other parasites in times of low host population is their ability to complete development in a single host. The Coccinellid *Cryptolaemus* has a much smaller chance for survival when the host population is low, due to the fact that from 1,300 to 1,400 mealy bug eggs are required to complete the development of a single individual.

5. It must have the ability to withstand transportation for long periods and at all seasons of the year.

6. It must be adapted for use in conjunction with other control practices.

7. It must be easily reared under mass production methods.

The biological control investigations have also indicated some of the conditions under which this form of control is particularly valuable, i.e., it makes possible the growing of certain varieties of susceptible plants under conditions where fumigation or other treatment cannot be carried out, and also the growing of crops that would be severely injured or destroyed by fumigation.

The work that has been done on this problem has shown that it is both practical and economical. Each parasite that has been investigated has contributed its share to the knowledge of the possibilities and limita-

tions of biological control in an environment that is largely artificial but in which the most important factors can be controlled.

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BIOLOGICAL CONTROL OF THE PEA MOTH *LASPEYRESIA NIGRICANA* STEPH.

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Introduction:—The pea moth, *Laspeyresia nigricana* Steph., appears to have been introduced from Europe into Canada some time prior to 1893. It was reported by Fletcher (1894, 1898) and Lochhead (1899) as doing considerable damage in certain areas throughout Eastern Canada. Reports from various sources (Treherne, 1911, Brittain, 1919, Twinn, 1934, Baker, 1937) reveal the extent of the areas subsequently showing damage. At the present time severe damage to late green peas and those grown for dry peas is being experienced in British Columbia, Eastern Quebec, New Brunswick and Nova Scotia. Reports indicate infestations in British Columbia as high as 100% of plants in peas grown for seed and in Nova Scotia 70% pod infestation. The pea moth appears to be practically free from attack by native or already established exotic parasites.

Conditions in England.—The pea moth being an introduced insect, the desirability of a study of the factors governing its prevalence in its native home is evident. At the expense of our Department, this work was carried out by Mr. Ewen Cameron, officer of the Farnham House Laboratory (Cameron 1938), by arrangement between Dr. Gibson and Dr. Thompson. Cameron found that on the average 10% of the pea pods in infested areas were attacked and that the commercial canners did not consider it of much consequence. He lists the following as the natural control factors (1) parasitic insects (2) parasitic nematode worms (3) entomophagous fungi, and states that parasitic insects are considered by far the most important. Three species of parasites have been reared, *Ascogas-*

*Prior to 1938 the work at Belleville was carried on by H. R. Boyce. Release of parasites and securing of larvae for recovery studies have been accomplished through the co-operation of R. Glendenning and Dr. A. D. Baker, of the Division of Entomology, and A. D. Pickett and Dr. J. M. Cameron, of the Nova Scotia Department of Agriculture.

ter quadridentatus Wesm., *Glypta haesitator* Grav. and *Angitia* sp. Together, these have accounted for the destruction of as high as 60% of the overwintering larvae. It seemed desirable therefore that attempts be made to establish these parasites wherever the pea moth is present in this country.

Biology of the Parasites.—*Ascogaster quadridentatus* like other members of this genus lays its egg in the egg of the host. It develops slowly within the host and is still in the first stadium when the host larva is mature and goes into hibernation. Early the following summer it develops rapidly, passes through the later larval stages quickly, leaves the host, spins a cocoon and emerges about the same time as the host. *Glypta haesitator* attacks the early larval stages of the host depositing its egg internally. It also remains in the first stage over the winter, goes through a rapid development in the spring and emerges as an adult somewhat later than the host moths and *A. quadridentatus.* Laboratory rearing of hibernating parasitized and unparasitized host material indicates that the parasites emerge at a time which is advantageous for successful attack on the host. *A quadridentatus* which oviposits in the egg of the host emerges shortly after the host moths while *G. haesitator* which attacks the early larval stages has the bulk of its emergence several days later. Moreover, the adults of *G. haesitator* are relatively long lived. It appears probable therefore that synchronization of host and parasite in the field will be good and that there will be no necessity for alternate hosts for the maintenance of either of these species. The sequence of emergence of the host *.A quadridentatus* and *G. haesitator* in the laboratory is presented graphically in Figure 1. The third species, *Angitia* sp. is also an internal parasite of the larval stages and overwinters in the host larva.

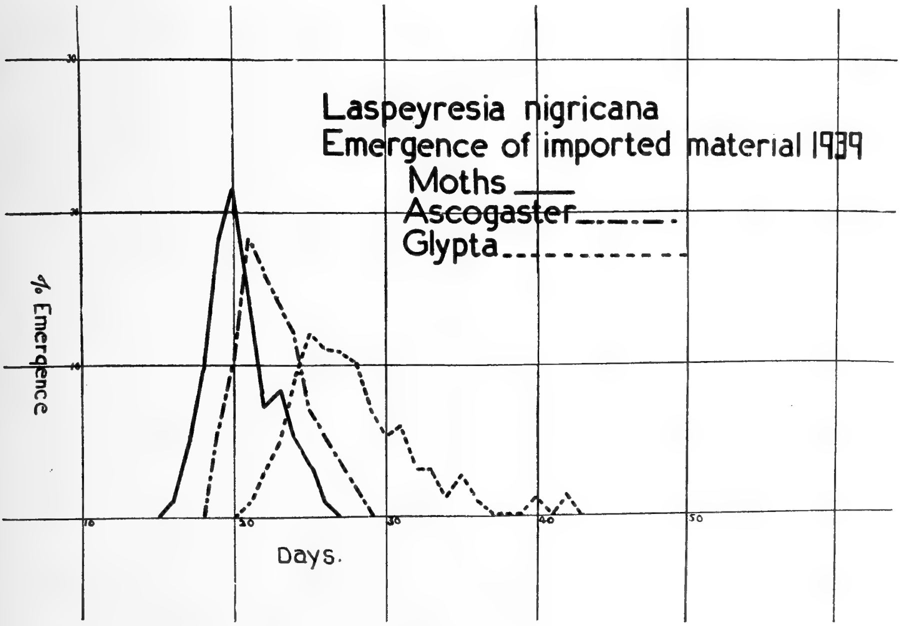

Figure 1

Collection of Parasites in England.—Annually since 1936 parasitized host larvae have been collected in England for shipment to Canda. The project has been rather costly due to the difficulty of locating sufficiently

infested pods to warrant the labor of working them over and also to the necessity of purchasing these in quantity to yield a sufficient number of larvae. The infested pods when secured were held until the larvae were mature, then the pods were opened and the larvae removed and placed on sterilized, sifted soil. This was then sent to Canada in tin boxes packed in outer containers of wood.

Storage of Parasitized Larvae.—Both the host and parasites have one generation a year and the parasites spend the winter in the mature host larvae. On arrival at Belleville in late August or September, after careful examination, the material was immediately placed in storage in its original containers.

The following numbers of larvae have been received:
1936 — 28,500 1937 — 30,000 1938 — 27,000

Experiments in storage at different temperatures have indicated that best results can be secured by storing at about 36 deg. F. Storage at 32 deg. F. gave slightly poorer results while at 20 deg. F. mortality of 95% occurred, and temperatures above 36 deg. F. were not sufficiently cold to retard development. Adverse storage conditions produced greater mortality among parasitized than among unparasitized larvae. Boxes of material were weighed at intervals to determine if loss of moisture was sufficient to indicate the adding of water to replace this loss. It was found that when the tin boxes were surrounded by excelsior loss of moisture was reduced.

Handling for Emergence.—Host cocoons are formed of silken fibres into which are incorporated particles of soil. Normally, these are found in the first few inches of soil. In the first year in which material was imported this environment was imitated by placing the cocoons in cages under about one half inch of moist sand. One small lot had the cocoons placed in a small box with a sliding glass top and a piece of moist blotting paper covering the bottom. The larvae kept in sand, gave a total emergence (host and parasite) of 1.1% while those in the wooden box gave a total emergence of 58.2%. In subsequent years all the material was handled in the wooden box type of emergence cage.

In 1938 and 1939 cocoons were removed from the soil by first sifting through 16 mesh screen followed by washing in running water. Practically all cocoons were thus "floated" off clean and uninjured, ready to be placed in emergence boxes. The small amount of residual material was picked over by hand.

Emergence Record

Year	No. Cocoons	Emergence: Host Moths	*Ascogaster quadridentatus*	*Glypta haesitator*	Other sp.
1936-37	28,500	763	96	20	22
1937-38	30,000	7931	1895	1448	27
1938-39	27,000	6869	5673	1438	98

Collection, Shipment and Liberation.—The parasites were collected by an air collector into cotton cages in which they were fed and stored until shipment. For shipment they were placed in copper screen cans containing moist excelsior. When shipped by railway express, these in turn were placed in ice boxes. In 1939 air express was used for shipment to British Columbia. In almost all cases the parasites shipped well and were in good condition when released in the field.

It was intended during 1939 to liberate parasites in three areas where heavy damage was expected, British Columbia, Eastern Quebec, and Nova Scotia. However, a visit to the pea growing regions of the Gaspe peninsula at the usual time of moth flight and egg deposition revealed that the lateness of the season had retarded the development of the pea moth considerably. The emergence of the parasites had been timed for an average season and unfortunately no parasites were available when the host insect was in the proper stage for attack in the Gaspe district so all releases were made in British Columbia and Nova Scotia. An effort will be made to remedy this situation in 1940.

The following table summarizes the liberations of imported parasites to date:

Year	Province	*Ascogaster quadridentatus*	*Glypta haesitator*	*Angitia* sp.
1937	Br. Columbia	65	12	
1938	Br. Columbia	880	734	5
	Quebec		379	
	Nova Scotia	900	10	11
1939	Br. Columbia	4377	809	21
	Nova Scotia	392	279	

Work with other Parasites.—Before the above-mentioned imported parasites of the pea moth were available for liberation, *Ascogaster carpocapsae* Vier and *Macrocentrus ancylivorus* Roh., parasites of the Oriental fruit moth, *Laspeyresia molesta* Busck, were propagated at the Belleville Laboratory and liberated as follows:

Year	Province	*Ascogaster carpocapsae*	*Macrocentrus ancylivorus*
1936	Br. Columbia	1266	1229
	Quebec	880	294
1937	Br. Columbia	50	

Conclusion.—The difficulty of synchronizing the releases of parasites in the widely separated areas has probably resulted in liberations being made at times which could hardly be considered optimum. In addition, adequate collections of host larvae for recovery studies have not been made in all areas. However, from the first large liberations of imported species in British Columbia, *Glypta haesitator* has been recovered in sufficient numbers to give promise of eventual establishment. This year a considerable quantity of material for recovery study is being secured from all liberation points, but data on emergence of parasites from this will not be available until the spring of 1940. Meantime, the information secured to date gives reason for optimism and the project is deserving of special attention at this time when the importation of peas from Europe will be greatly curtailed if not completely cut off. An increase in the production of dried peas in Canada will almost certainly increase the troubles with this pest.

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METHODS AND MATERIALS OF A NEW TECHNIQUE FOR USING POMACE FLIES IN BIOLOGICAL TESTS WITH CONTACT INSECTICIDES

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This paper describes a technique for the rearing and using of pomace flies for biological tests with contact insecticides. It is an alternative method to those used elsewhere. So far we have used only two test insects; the pomace flies, *Drosophila melanogaster* Meig. and *D. hydei* Sturt but it is not unlikely that the method can be adapted for testing contact insecticides against other flies as well.

REARING THE FLIES

Culture Medium.—We have had excellent results with the following medium when used under the conditions described in this paper. A convenient amount may be made up using the following quantities of materials:

Potatoes	300 grams
Water	200 cc
Royal Yeast	4 cakes

The potatoes are cut up and boiled in the water. As soon as they are cooked the excess liquid is poured off into a separate container to cool. When it has reached 90 deg. F., or lower, 100 cc is measured off into a beaker. The four yeast cakes are added to this and allowed to soak for an hour or more. The potatoes are finely mashed while they are still hot. After they have cooled, the yeast-liquid mixture is added to them and the whole mass is then thoroughly mixed. The medium should be used soon after mixing. Sometimes it is desirable to cook enough potatoes to last over a period of several days. In this case the mashed potato should be kept in a cool place until needed. The yeast cakes are soaked in 100 cc of liquid and then mixed with the potato just before the medium is used.

Egg-laying Cage—This is a frame cage approximately 9 inches long, 5 inches wide, and 5 inches high, having a wooden bottom and light cotton cloth sides, back and top. The upper part of the front end has a glass window, 3½ inches by 4½ inches, and the lower part is fitted with a cotton sleeve large enough to admit the food tray.

The waxed wooden food tray (6½ inches long, 4½ inches wide, and 1 inch deep) is filled with the culture medium and put into the egg-laying cage, together with about 600 healthy flies.

Five days after being put with the flies, the tray of culture medium and accumulated eggs and larvae is removed from the egg-laying cage and a fresh tray of culture medium put in its place.

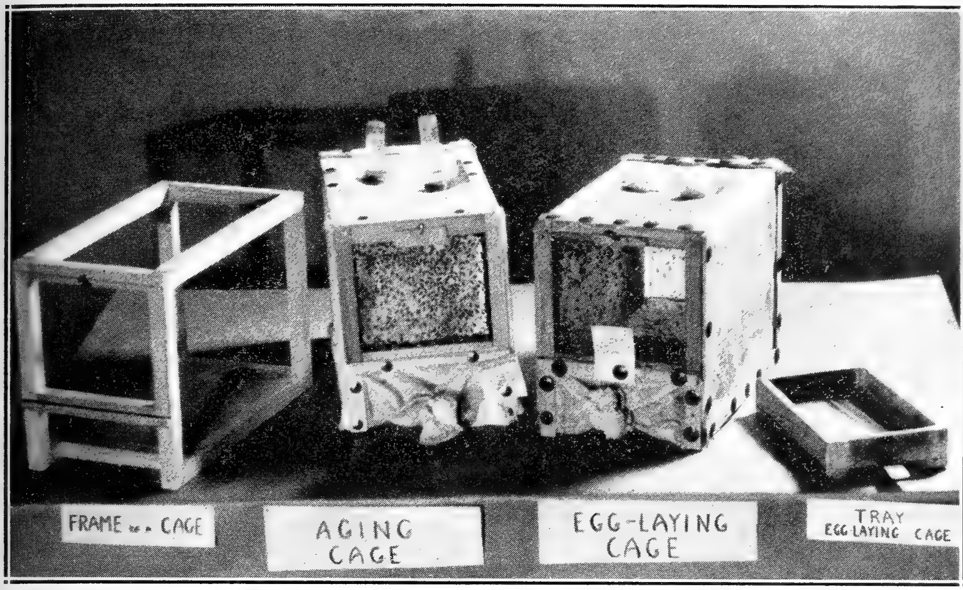

Plate 1.—Aging Cage, Egg-laying Cage. Type of cage used for oviposition and for aging of flies. Separate items (left to right), (1) Wooden frame and bottom of the cage, (2) Cage as used for aging flies, (3) As used for oviposition, (4) Tray for culture medium in egg-laying cage.

Maturing Cage.—The culture medium with accumulated larvae and eggs is taken from the tray and put on the "floor" at the back end of a flat sided gum jar which is kept lying on its side. If necessary, a little fresh culture medium is added. The front half of the "floor" is then covered with clean, dry, wheat bran, to a depth of approximately ½ or ¾ of an inch. This absorbs excess moisture and also provides a favourable medium for pupation. The opening is covered with a square of cotton held in place by means of an elastic band. Both the egg-laying cages and the maturing cages are kept in the same constant temperature chamber, at a temperature of approximately 70 deg. F. The relative humidity in this cage varies somewhat but is approximately 70 per cent most of the time.

Spraying The Flies

Aging Cage.—As the flies appear in the maturing cage, they are transferred at intervals of either one or two days, to a third cage in which they are kept until ready for spraying. A fresh cage is used, of course, for all flies transferred on any one day. This cage is constructed the same as the egg-laying cage. In fact, the same cage may be used for either purpose. When used for aging, the food and moisture requirements of the flies are supplied by means of a long cotton-wool plug soaked with a 3 per cent honey solution. This is done by filling a long vial (15 m.m. x 100 m.m.) with the honey solution and then stoppering it with a wad of cotton batting. The vial is then turned upside down and inserted through a close fitting hole in the cloth top so that the honey solution will seep down and replace that used by the flies and by evaporation. Two of these feeding vials are generally inserted in the roof of each cage. Rubber bands placed about the vials prevent them from dropping into the cage.

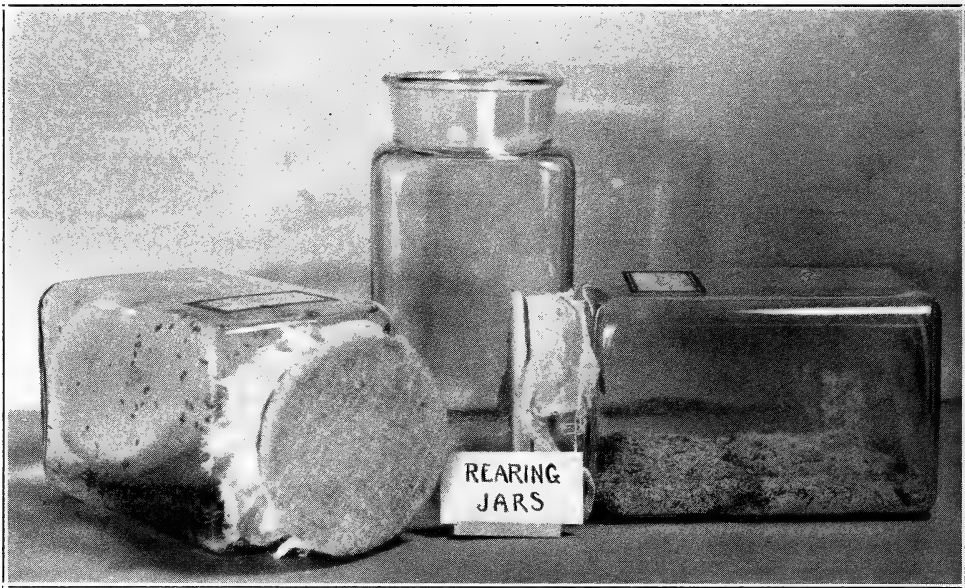

Plate 2.—Rearing Jars. Type of jar used for maturing the flies. Separate items (left to right), (1) Jar of pupating larvae, (2) Empty jar, (3) Jar freshly charged showing wheat bran in front end, and culture medium plus eggs and larvae at back end.

The cages of aging flies are kept in a large constant-temperature chamber thermostatically controlled at 70 deg. F.

Lantern Globe Spray Chamber.—The flies are sprayed in closed lantern globes. As many as 1000 *Drosophila melanogaster* may be put in a globe and sprayed at one time. However, approximately 300 flies has been found to be a very satisfactory number to handle in a globe. If too many flies are used at a time, it is difficult to get an accurate count of the dead if the mortality rate is high.

The globe is closed at the large (lower) end with a good grade of dusting cotton, securely fastened in place by means of a wire ring. The same kind of cloth is used to cover the upper end and is held in place with an elastic band. A ⅜ inch hole in the cloth in the top allows for the entry of flies and also for the insertion of an inverted feeding vial filled with a 3 per cent honey solution and stoppered with cotton batting. The feeding vial is left in position except during the entry of flies and when spraying.

Flies may be aged in the globes rather than in an aging cage. In some of our work it has been found more convenient to do so; particularly when we want to keep separate records on flies taken from different jars.

Spray Apparatus.—This consists of an atomizer, arranged to spray vertically upwards, an air pump run by an electric motor, an air tank equipped with a device for keeping the air pressure constant, and a pressure gauge so that the operator may know at all times whether the required pressure is being maintained.

The atomizer is the Tattersfield type No. 2 as described in the Annals of Applied Biology, Volume 21:691-703. It is so made that the fineness of spray and speed of output may be easily regulated. The nozzle of the at-

omizer is directed upwards to project about $\frac{1}{8}$ inch through a hole in the centre of a circular platform, which is 5 inches in diameter. The platform is free to revolve about the spray nozzle but the latter does not form the axis upon which it turns. This is provided by means of a short hollow tube which closely surrounds the nozzle but is supported by the same base plate as that to which the other parts of the atomizer are fastened. This device prevents any pressures applied to the platform in process of turning it from being transmitted to the nozzle and thereby throwing the latter out of adjustment. The base plate of the atomizer acts as a support for the revolving platform.

The air pump and motor is a combination outfit produced by the DeVilbiss Manufacturing Company Limited, and listed by them as the "DeVilbiss $\frac{1}{4}$ H.P. Portable Electric Spray-Painting Outfit—Type N C-601.; The air line from the pump leads to a 3 gallon air tank, the pressure in which can be regulated by means of a sliding weight on the lever attached to the escape valve. The pressure gauge which is connected to the air line leading to the atomizer consists of a U-tube (manometer) which will accomodate 35 inches of mercury.

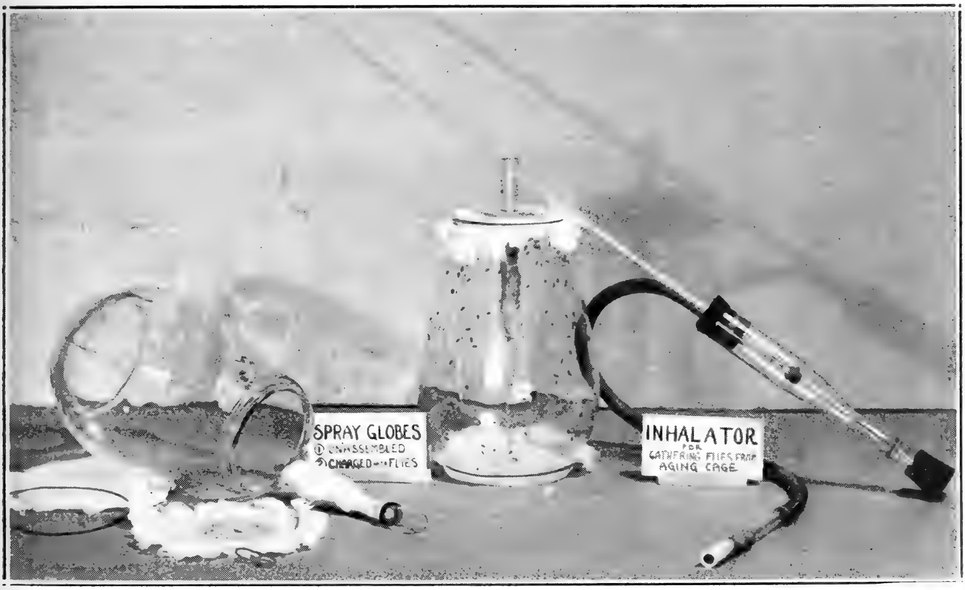

Plate 3.—Spray Globes and "Inhalator". Spray globes and apparatus for charging them. Separate items (left to right); (1) Spray globe showing parts before assembling, (2) Spray globe completely assembled and charged with flies, (3) Type of aspirator used for transferring flies.

Method of Spraying.—The feeding vial is removed from the hole in the centre of the upper cloth of the globe which is immediately inverted and placed on the atomizer platform so that the nozzle projects through the opening in the cloth. A fixed guiding ring which is slightly larger than the outside diameter of the lower end of a lantern globe is fastened to the upper surface of the platform. This serves to centre automatically each globe over the spray nozzle. The required amount of spray, 1 c.c. for instance, is put in the spray reservoir by means of a pipette. The cloth of what is now the upper end of the globe is tapped with a padded cover plate to cause the flies to leave this part of the spray chamber. The plate is then put on the globe as a cover and at the same time, the air, which has already

been brought up to proper pressure, is allowed to enter the atomizer and drive the spray into the globe. The latter is rotated during the actual spraying in order to ensure that the interior is evenly sprayed. Since the top of the globe is covered the spray tends to form a cloud or mist which settles fairly evenly over the whole interior surface, including the floor, of the spray chamber. Using 15 pounds air pressure, there is some tendency for the centre of the upper covering of the globe to receive a little heavier spray than the rest of the spray chamber. It is for this reason that the flies are chased from this section of the chamber just as the spraying is started. The padding on the cover absorbs any excess spray which might gather on the cloth of the globe. As soon as the spraying is completed, the globe is removed from the platform and the feeding vial is put back in place. The globe is then put in the low-humidity constant-temperature chamber where it is left until final observations are taken. The room is kept at a temperature of 70 deg. F. for spraying.

Method of Transferring Flies.—This is done by means of an aspirator. Suction on the mouth piece draws flies into a collecting chamber. A piece of fine tulle over the inlet of the mouth tube prevents the inhaling of flies, particles, etc., by the operator. The collecting tube is of glass and long enough to reach the whole length of a gum jar or aging cage. A large glass vial (22 m.m. x 200 m.m.) serves as a collecting chamber when transferring flies from a gum jar to an aging cage. A gum jar may be completely emptied of flies by means of this piece of equipment. Also, there is little chance of many flies escaping into the room.

When transferring flies to the spray globes, the collecting chamber of the aspirator consists of a tube 22 m.m. in diameter which is tapered to a 7 m.m. opening at the distal end. The last 30 or 35 m.m. should be as straight walled as possible as this portion of the tube is marked off for measuring out flies. Such measurements are only approximations of course, but nevertheless, they are close enough for the purpose. The distal end of this collecting chamber is closed by being inserted into a hole in a cork. This hole is drilled only about half way through a No. 2 rubber cork. It is just large enough to give a snug fit around the end of the chamber. If the end thus corked is tapped lightly on the bench, all the flies contained in the chamber will be bunched at this end and can be measured. When enough flies have been collected to measure up to, say, the 300 fly mark, the flies are flipped back to the opposite end, the distal cork removed, and the distal end of the chamber inserted in the hole in the top of a spray globe. A few taps on the side of the collecting chamber cause all the flies to drop through into the globe. The whole operation of collecting approximately 300 flies from an aging chamber, measuring them and then emptying them into spray globe, should not take more than a minute or two. The hole through which the flies are introduced is closed by the insertion of a feeding vial.

Record Taking.—Final records are generally taken one or two days after spraying. However, the number of dead flies in a globe may be counted at several successive intervals before a final count is taken, if desired. After taking the last count of dead flies, the living ones are killed. All flies are then removed from the globe and dumped on a sheet of white paper in order to count the total number of flies treated. One may now calculate the percentage mortality at the various times when counts of dead flies were made. A Vedeer hand counter has been found very convenient for counting flies, both in the globes and after all are killed.

A counting stand was made for separating and counting the dead from the living flies while in the globe. This consists of a circular movable piece of wood, somewhat larger in diameter than the base of the globe. on which is marked a black ring of the same diameter as the bottom of the globe. The area inside this ring is marked off into segments by means of heavy black lines. A heavy radial line marks the point at which counts are started. In order to facilitate turning, this wooden circle is mounted on a spindle sunk in a wood base. By placing the base of the globe over this sub-divided circle, the dead flies lying on the cloth at the bottom are counted in lots separated by the black lines showing through the cloth. A minority of the dead flies will be found sticking to the sides of the globe. Counting of these is facilitated by marking the sides of the globe off in vertical sections with a china-marking pencil. A white board fastened vertically to one edge of the base of the counting stand forms a background against which to count these flies.

The living flies in a globe may be killed by placing the globe over a jar partly filled with ether-soaked cotton. A cover is put over the top of the globe to prevent escape of the ether fumes.

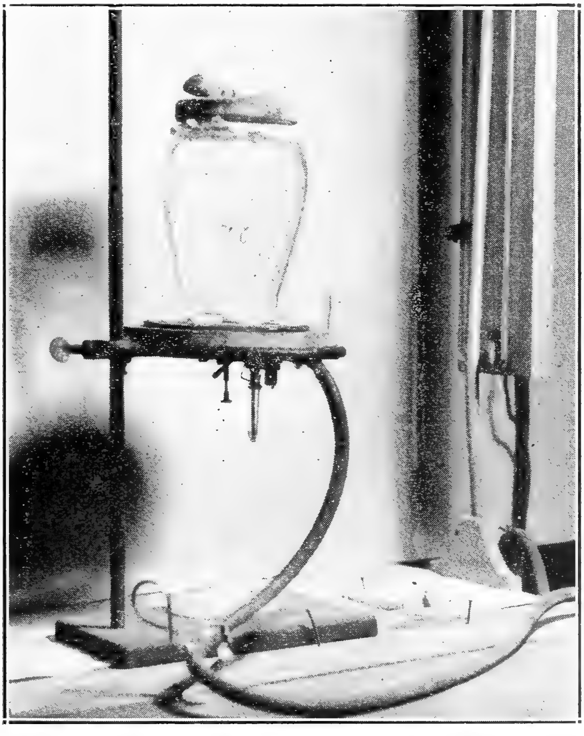

Plate 4.—Spray apparatus showing spray globe in position over the nozzle and ready for spraying. The manometer is on the right. The rubber tubes attached to the spray apparatus and to the manometer lead from the air pressure equipment which is underneath the spray bench.

SOME NOTES ON THE PRESENT TECHNIQUE

By raising *Drosophila melanogaster* on the culture medium and in the manner described in this paper, we have had no serious trouble with moulds. Since the eggs are laid over a period of only a few days, the sub-

sequent period of emergence is also only a few days. If enough larvae develop to use up nearly all the food supplied, this emergence will be heavy. Approximately ten thousand flies from one jar in five days is not at all unusual. If too many eggs are laid more larvae will develop than can be supported by the amount of culture medium the containers will conveniently hold. This results in under-sized flies. Another advantage of this technique is that the larvae complete development, pupate, and the resulting flies are removed before the culture medium gets in bad condition. Since the culture medium is in a cloth sided cage during the 4 or 5-day egg laying period, it does not get "soupy" but instead, dries enough to counter-balance the effect of breakdown of the medium. As a result, if the culture is of the proper consistency when put in the trays, it should be firm but still damp when transferred to the gum jar. When put in the jar in this condition, the addition of one or two tablespoons of fresh culture medium will not cause more excess moisture to form than can be absorbed by the bran in the front end of the jar. A jar in good condition when discarded is one in which the bottom layer of bran is moist but the upper half is fairly dry. Under conditions like these most of the pupation takes place in the bran and the sides of the jar keep quite clean. By using the jar on its side instead of on its bottom, the area available for culture medium and bran is almost doubled, besides facilitating handling of the flies.

For the removal of flies from a gum jar, it is placed on a stand of such a height that the mouth of the jar is only four to six inches below the level of the eyes of the operator. One back corner of the jar should be directed toward a good light. This attracts most of the flies to this corner from which they may be most easily removed with the aspirator. In order to remove the flies from a jar, just enough of the cotton cover is pulled from under the elastic band to permit insertion of the collecting tube of the aspirator. If this is done with reasonable care, very few flies will escape, particularly since most of them have been attracted toward the light coming in the other end. The bulk of the flies are gathered very quickly after the operator has had some experience with the aspirator. Getting the last few flies scattered around the inside of the jar is likely to prove somewhat tedious.

The use of wicks saturated with fresh sugar or honey solution in the aging cages provides a source of nourishment of fairly standard quality for all lots of flies. The potato-yeast culture medium was tried for awhile in the aging cages. The difficulty with it is that each lot varies from day to day and different lots are liable to vary one with the other. The results of spraying tests with nicotine sulphate at the rate of 1 part nicotine alkaloid per hundred of water, indicates that the 3 per cent honey solution is a very satisfactory food medium for aging flies. It was compared against the potato-yeast culture medium and a 3 per cent sugar solution. Flies have been kept alive with little mortality for a period of as long as one month in an aging cage with the honey solution as their only source of nourishment. A few flies were still alive after two months in such a cage. As many as 23,000 flies have been kept in one cage. Spraying tests do not indicate any significant correlation between the number of flies kept in a cage and their susceptibility to nicotine sulphate 1-100. It has been noted however, that the last lot of flies taken from a cage are generally more susceptible to this spray than the lots of flies withdrawn previously from the same cage.

The use of lantern globe spray chambers has proven very satisfactory. Twenty-five globes can be charged with flies and sprayed within a period of one hour by an operator working alone. In other words, as many as

10,000 flies can be segregated in 400-450 fly lots and sprayed in that time. Spray tests with nicotine sulphate 1 part actual alkaloid per 100 parts of water (1-100) do not indicate any significant correlation between number of flies per globe and percentage kill.

It is worth noting that the present culture technique is quite flexible adapting itself to the culturing of flies in many different ways for different purposes. For instance, one can very easily obtain large numbers of flies of definite known ages. When the gum jars are completely emptied every twenty-four hours and the flies put in separate aging cages each time, the operator is able to have at hand flies known to be within 24 hours of 2, 3, 5, 10, or any other number of days old. The method can be easily adapted to population studies of various kinds.

Spraying inside lantern globes does away with the necessity of setting up the atomizer inside a fume chamber when spraying nicotine solutions. Even when using 20 per cent solution the operator can hardly detect the nicotine fumes, although our spray apparatus is set up in the middle of a room in the basement of the laboratory.

The actual temperature prevailing in a spray-globe at the time of spraying as well as during the period of several hours following when the interior of the globe is drying off, is a matter of considerable interest and importance. The chief factor governing this is the actual temperature of the room in which the spraying is done. The spray temperature inside a globe follows that of the room temperature very closely, due to the fact that from the time spraying starts until the inside of a globe has almost completely dried off, the spray chamber contains a water-vapor saturated atmosphere. The spray temperature in an open room as recorded by a thermometer held in the direct path of the spray, is a wet bulb temperature which is, of course, conditioned by the relative humidity of the room as well as the dry bulb temperature of the room. Until thermometer readings were taken inside globes, both during the time of spraying as well as during the subsequent drying off period, it was supposed that the relative humidity of the room during this time would be a significant factor which should be known and recorded. However, it turns out that this is not so. As far as spray temperatures are concerned, the operator need only make sure that he sprays at a constant room temperature.

It is also of interest to know that the large fruit fly *Drosophila hydei* is easily reared on the potato-yeast culture medium and in the manner described in this paper. One must be careful however, not to have too many flies in the egg-laying cage. Fifty to seventy-five of these flies will, in a few days produce all the larvae that can be properly raised in a gum jar. We have had no trouble with moulds in our *D. hydei* cultures.

We have made more or less extensive studies of several factors as they relate to the susceptibility of pomace flies to nicotine sulphate. These were done in an effort to locate the factors responsible for inconsistencies of mortality resulting when spraying different lots of flies at different times. The following factors were studied: (1) Age of flies at time of spraying; (2) Relative humidity to which flies were subjected both before and after spraying, (3) Food medium for aging flies, (4) Number of flies in a globe at time of spraying, (5) Effect of varying air pressure, duration of spray period, and amount of spray material used per test, (6) Age of parent flies when any particular lot of eggs are laid, i.e., preoviposition period.

The most extensive studies have been made on two of these; the age of flies at time of spraying and on the relation of the preoviposition period of the parent to the vitality of their offspring. The latter is a problem of considerable general biological interest.

SOME FUMIGATION METHODS EMPLOYED IN THE UNITED STATES TO PREVENT THE SPREAD OF THE JAPANESE BEETLE

By H. A. U. Monro

Division of Plant Protection, Montreal, P.Q.

Owing to the close proximity to the Canadian border of infestations of the Japanese beetle *Popillia japonica* Newm. and to the fact that treated foodstuffs are being shipped into Canada from the quarantined area established for this insect, the fumigation methods employed to control the spread of the beetle are of great interest to our authorities. Through the kind co-operation of officials of the United States Bureau of Entomology and Plant Quarantine the writer was permitted to observe much of the work being carried on in the states of Delaware and New Jersey during the 1939 flight season of the beetle.

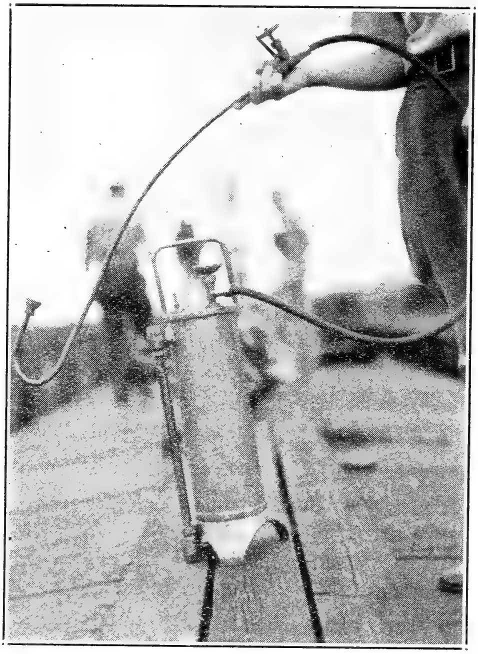

Fig. 1.—Methyl bromide applicator for refrigerator car fumigation. Original photograph.

The enforcement of the Japanese beetle quarantine may be divided into two fields of endeavour, inspection and treatment. The treatment work may be subdivided into, firstly, the year-round treatment of potted plants, nursery stock, and soil, to prevent the spread of all stages, and,secondly, the seasonal treatment of fruits and vegetables during the flight of the adult beetles.

1—Contribution No. 10 from The Plant Protection Division. Production Service, Department of Agriculture, Ottawa, Canada.

The introduction of new fumigation treatments has greatly facilitated the movement of produce outside the quarantined area, with consequent benefit to the shippers.

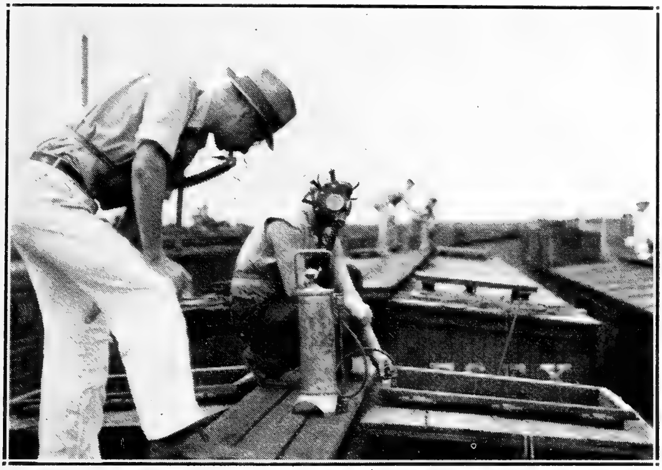

Fig. 2.—Using methyl bromide applicator in refrigerator car fumigation. Original photograph.

Treatment of potted plants and nursery stock.—In the year-round treatments of nursery products and soil, in previous years the chief practice was the application of lead arsenate to large areas of land in the nurseries. The introduction of efficient fumigation methods appears to have reduced the necessity for this procedure, as only the stock actually being shipped out has to be treated. Methyl bromide is now used extensively for this fumigation work. It is usually applied at the rate of 2.5 pounds of fumigant per 1000 cubic feet of vault space for a period of 2.5 hours at a temperature of not less than 63 deg. F.

Many of the growers in the quarantined area have erected their own fumigation chambers which usually vary from 100 to 200 cubic feet in capacity, constructed with a 2 by 4 inch wooden framework, with three-ply wood on the outside and sheets of soldered galvanized iron on the inside. All the vaults have to be equipped with approved gas circulating devices, often one-sixth horse power household furnace blowers, and with evaporating pans underneath the methyl bromide inlet to vaporize the fumigant. Heating coils are usually placed near the floor and the circulating blower can be used to force the gas up the exhaust pipe at the end of the treatment period.

A wide range of nursery and greenhouse plants have been subjected to this treatment and only a small percentage of the varieties tested have suffered any damage.

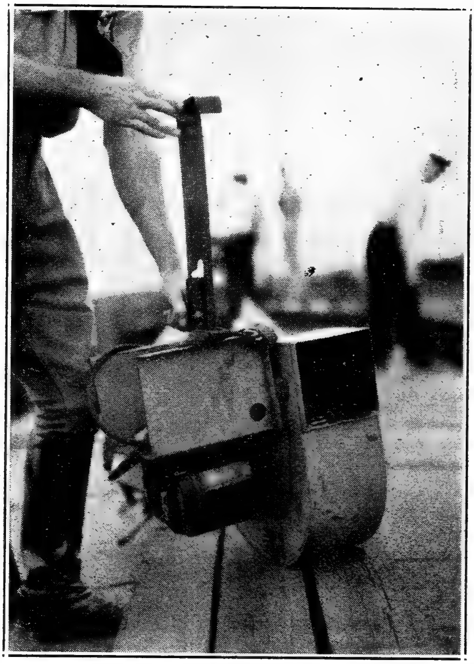

Fig. 3.—Type of blower used in fumigation of refrigerator cars with methyl bromide. Original photograph.

Fumigation of fruits and vegetables.—The tolerance of many fruits and vegetables to methyl bromide fumigation has permitted the shipping of these products outside the quarantined areas in refrigerator cars. The cars are concentrated at some focal point where the fumigation may be carried on under the supervision of government inspectors.

In some places special wiring has been run alongside the railroad to permit operation of the blowers, but the introduction of economical gasoline-powered blowers may render this unnecessary. The dosage required is 2 pounds per 1000 cubic feet or five pounds for the standard refrigerator car. The car temperature must be at least 70 deg. F. The fumigant is released from special applicators with the spray nozzle at the end of a "U" shaped copper tube, so as to force the fumigant towards the roof of the car. At one end of the car three pounds are released from one applicator across the face of a blower of about 750 cubic feet per minute capacity, and simultaneously the balance of two pounds is released at the other hatch, without a blower but in line with the blower at the other end of the car. The hatches are then tightened and the car left untouched on the siding for the exposure period of two hours. At the end of this time the doors and hatches are carefully screened and aeration takes place. After adequate ventilation the cars are allowed to proceed, if necessary under refrigeration.

So far, for commercial shipments, this treatment has been approved for the following fruits and vegetables: white potatoes, sweet potatoes, onions, tomatoes, snap beans, Lima beans, sweet corn, cabbage, carrots, beets, apples, and peaches.

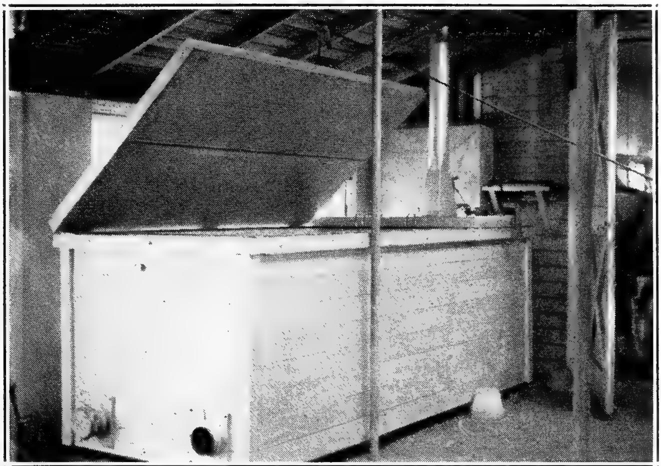

Fig. 4.—Type of "box" used for methyl bromide fumigation of nursery stock in New Jersey. Original photograph.

Acknowledgment.—The author wishes to acknowledge the kindness of the officials of the United States Bureau of Entomology and Plant Quarantine and especially Dr. L. A. Hawkins, who made arrangements for him to witness these procedures, and Dr. H. C. Donohoe and Mr. V. A. Johnson, who explained them to him.

A PRELIMINARY LIST OF THE INSECTS COLLECTED IN THE LAURENTIDE PROVINCIAL PARK, MONTMORENCY COUNTY, QUEBEC

By GUSTAVE CHAGNON, FATHER OVILA FOURNIER

University of Montreal

In 1938, the University of Montreal opened a Biological Station in the Laurentide Provincial Park subsidized by the Provincial department of Fisheries for the study of the Speckled Trout (*Salvelinus fontinalis*).

The 5,000 sq. miles of the park are covered with timber, mostly composed of birch and coniferous trees, and also with many lakes and rivers. It is an absolute wilderness averaging from 1,000 to 3,000 feet high, between the 71 and 72 deg. longitude W. and 47 and 48 latitude N. in the Canadian Shield. The lotic and lentic habitats offer a great variety of conditions for insect life.

The biologists of the Station collected intensively during the seasons 1938 and 1939 and the following species have been identified:

ORDER ORTHOPTERA

ACRIDIDAE

Acridium ornatum (Say), *Acridium granulatum* Kby., *Tettigidea lateralis parvipennis* (Harris), *Melanoplus bivittatus* (Say), *Melanoplus femur-rubrum* (De Geer).

ORDER HEMIPTERA

CYDNIDAE

Galgupha unicolor Pal. de Beauv.

PENTATOMIDAE

Peribalus limbolarius Stal., *Mormidea lugens* Fab., *Euschistus euschistoides* Voll., *Euschistus tristigmus* Say, *Coenus delius* Say, *Cosmopepla bimaculata* Thom, *Meadorus lateralis* Say, *Elasmostethus cruciatus* Say, *Podisus maculiventris* Say.

LYGAEIDAE

Nysius ericae Schill., *Ischnorhynchus resedae* Panz., *Eremocoris ferus* Say, *Ligyrocoris diffusus* Uhl.

ARADIDAE

Aradus abbas Bergr.

MIRIDAE

Lygus pratensis L., *Lygus vanduzeei* Kngt., *Poecilocapsus lineatus* Fab.

GERRIDAE

Gerris marginatus Say, *Gerris* sp.

CORIXIDAE

Arctocorixa sp.

ORDER HOMOPTERA

CICADELLIDAE

Idiocerus alternatus Fitch, *Oncopsis variabilis* Fitch, *Oncopsis pruni* Prov., *Cicadella gothica* Sign., *Draeculacephala mollipes* Say, *Gypona octolineata* Say, *Platymetopius acutus* Say.

FULGORIDAE

Oliarius humilis Say.

ORDER COLEOPTERA

CICINDELIDAE

Cicindela longilabris Say, *Cicindela tranquebarica* Hbst.

CARABIDAE

Bembidion versicolor Lec., *Bothriopterus* (*Pterostichus*) *pennsylvanicus* (Lec.), *Platynus bogemanni* Gyll., *Platynus cupripennis* Say, *Platynus sinuatus* Dej., *Harpalus herbivagus* Say, *Harpalus pennsylvanicus* Dej., *Agonoderus pallipes* (Fab.)

HALIPLIDAE

Haliplus ruficollis DeG., *Haliplus cribrarius* Lec.

DYTISCIDAE

Laccophilus maculosus Germ., *Coelambus punctatus* Say, *Coelambus nubilus* Lec., *Coelambus impressopunctatus* Schall., *Hydroporus undulatus* Say, *Hydroporus fuscipennis* Kies., *Hydroporus griseostriatus* DeG., *Agabus ambiguus* Say, *Ilybius biguttulus* Germ.

HYDROPHILIDAE

Tropisternus glaber Hbst., *Hydrobius fuscipes* L., *Enochrus hamiltoni* Horn.

STAPHYLINIDAE

Anthobium sp., *Philonthus tetragonocephalus* Notm., *Philonthus politus* L., *Quedius molochinus* Grav., *Staphylinus badipes* Lec., *Tachyporus chrysomelinus* L., *Baryodma bimaculata* Grav.

LAMPYRIDAE

Lucidota atra (Fab.), *Lucidota corrusca* (L.), *Photuris pennsylvanica* (DeG.)

CANTHARIDAE

Podabrus puncticollis (Kby.), *Podabrus* sp., *Cantharis* sp.

CEPHALOIDAE

Cephaloon lepturides Newm.

OEDEMERIDAE

Ditylus coeruleus Rand.

MORDELLIDAE

Anaspis rufa Say.

MELOIDAE

Pomphopoea sayi Lec.

PYTHIDAE

Pythoniger Kby.

PYROCHROIDAE

Schizotus cervicalis Newn.

ELATERIDAE

Adelocera obtecta (Say), *Athous cucullatus* (Say), *Ludius costalis* (Payk.), *Ludius nigricornis* (Panz.), *Ludius triundulatus* (Rand.), *Ludius kendalli* (Kby.), *Ludius tarsalis* (Melsh.), *Hemicrepidius memnonius* Hbst., *Hemicrepidius decoloratus* (Say), *Hypnoidus striatulus* (Lec.), *Agriotes oblongicollis* (Melsh.), *Agriotes limosus* (Lec.), *Agriotes stabilis* (Lec.), *Elater apicatus* Say, *Elater rubricus* Say.

BUPRESTIDAE

Dicera tenebrosa Kby., *Buprestis maculativentris* Say, *Melanophila acuminata* DeG., *Melanophila fulvoguttata* Harr., *Chrysobothris sexsignata* Say, *Chrysobothris trinervia* Kby., *Chrysobothris scabripennis* Cast., *Chrysobothris dentipes* Germ.

HELMIDAE

Stenelmis vittipennis Zimm., *Helmis quadrinotata* Say.

HELODIDAE

Cyphon obscurus Guer.

DERMESTIDAE

Byturus unicolor Say

BYRRHIDAE

Cytilus alternatus Say, *Byrrhus americanus* Lec.

COCCINELLIDAE

Hyperaspis undulata Say, *Psyllobora vigintimaculata* Say, *Hippodamia parenthesis* Say, *Hippodamia tredicimpunctata* L., *Coccinella tricuspis* Kby., *Adalia bipunctata* L., *Anatis quindecimpunctata* Oliv.

TENEBRIONIDAE

Upis ceramboides (L.)

MELANDRYIDAE

Melandrya striata Say.

SCARABAEIDAE

Aphodius granarius (L.), *Dichelonyx elongata* (Fab.)

CERAMBYCIDAE

Tetropium cinnamopterum Kby., *Criocephalus agrestis* (Kby.), *Rhagium lineatum* Oliv., *Evodinus monticola* (Rand), *Acmaeops proteus* (Kby.), *Acmaeops pratensis* (Laich.), *Leptura chrysocoma* Kby., *Leptura nigrella* Say, *Callidium violaceum* (L), *Phymatodes dimidiatus* (Kby.), *Xylotrechus undulatus* (Say), *Xylotrechus colonus* Fab., *Neoclytus muricatulus* (Kby.), *Monochamus scutellatus* (Say), *Pogonocherus mixtus* Hald., *Pogonocherus penicellatus* Lec.

CHRYSOMELIDAE

Donacia cincticornis Newm., *Donacia palmata* Oliv., *Donacia proxima* Kby., *Orsodacne atra* (Ahr.), *Syneta ferruginea* (Germ.), *Paria canella aterrima* (Oliv.), *Leptinotarsa decemlineata* (Say), *Galerucella nymphaeae* L., *Chalcoides fulvicornis* (Fab.), *Epitrix cucumeris* Harr.

ORDER LEPIDOPTERA

PAPILIONIDAE

Papilio glaucus turnus L.

PIERIDAE

Colias interior Scud., *Pieris napi* L.

NYMPHALIDAE

Brenthis myrina Cram.

LYCAENIDAE

Lycaenopsis pseudargiolus Bdv. & Lec.

HESPERIIDAE

Carterocephalus palaemon Pall.

SPHINGIDAE

Sphinx gordius Cram.

PHALAENIDAE

Euxoa messoria Harr.

GEOMETRIDAE

Eulype hastata L., *Ectropis crepuscularia* Schiff., *Metanema determinata* Wlk., *Caripeta divisata* Wlk., *Sicya macularia* Harr.

ORDER DIPTERA

XYLOPHAGIDAE

Xylophagus reflectens Wlk.

STRATIOMYIIDAE

Sargus cuprarius L., *Microchrysa polita* L., *Stratiomys badia* Wlk., *Odontomyia pubescens* Day, *Odontomyia virgo* Wied.

TABANIDAE

Chrysops carbonarius Wlk., *Chrysops celer* O.S., *Chrysops vittatus* Wied., *Chrysops exitans* Wlk., *Chrysops cuclux* Whit., *Chrysops indus* O.S., *Chrysops niger* Macq., *Chrysops wiedmanni* Kr., *Tabanus affinis* Kby., *Tabanus lasiopthalmus* Macq., *Tabanus reinwardtii* Wied., *Tabanus zonalis* Kby., *Tabanus lineola* Fab., *Tabanus orion* O.S.

ASILIDAE

Dasyllis thoracica Fabr., *Dasyllis posticata* Say., *Cyrtopogon falto* Wlk., *Asilus novae-scotiae* Macq.

DOLICHOPODIDAE

Dolichopus cuprinus Wied., *Dolichopus comatus* Lw., *Dolichopus scoparius* Lw.

SYRPHIDAE

Melanostoma obscurum Say, *Syrphus perplexus* Osburn, *Syrphus ribesii* L., *Syrphus arcuatus* Fall., *Syrphus torvus* O.S., *Epistrophe grossulariae* Mg., *Sphaerophoria cylindrica* Say, *Sericomyia militaris* Wlk., *Eristalis arbustorum* L., *Eristalis transversus* Wied., *Eristalis tenax* L., *Eristalis dimidiatus* Wied., *Helophilus similus* Macq., *Mallota posticata* Fab., *Syritta pipiens* L.

METOPIIDAE

Cynomya cadaverina Desv., *Calliphora viridescens* Desv., *Calliphora erythrocephala* Meig.

MUSCIDAE

Morellia micans Macq., *Spilaria multisetosa* Schnabl., *Stomoxys calcitrans* L.

ORDER HYMENOPTERA

SIRICIDAE

Urocerus flavicornis Fab.

CRABRONIDAE

Crabro americanus (Leach), *Trichiosoma triangulum* Kby.

TENTHREDINIDAE

Tenthredo basilaris Say, *Tenthredella rufopecta* (Nort.), *Tenthredella verticalis* (Say).

ICHNEUMONIDAE

Amblyteles laetus (Brulle), *Amblyteles rufiventris* (Brulle), *Ephialtes conquisitor* (Say), *Rhyssa lineolata* (Kby).

CHRYSIDIDAE

Chrysis perpulchra Cress.

FORMICIDAE

Camponotus herculeanus (L.)

ANDRENIDAE

Andrena wilkella Kby., *Andrena vicina* Sm.

THE CLASSIFICATION OF FOREST INSECT INJURY

By A. R. Gobeil

Entomological Service, Dept. Lands and Forests, Quebec

The increasing distribution of the European Spruce Sawfly and damage caused by it during recent years has lead the Quebec Entomological Service to develop a permanent Survey Service for this and other injurious forest insect pests in the province. Such surveys are carried out by two different organizations: 1.—By the forest engineers in the course of forest inventory work. 2.—By fire-rangers of the Quebec Protection Service as well as Forest Protective Associations.

After two years of preliminary work we have adopted standard methods which are herewith presented for the benefit of forest industries operating in Quebec.

Methods Used in Forest Survey

Entomological information is collected in connection with other activities such as general line surveys of the forests in a district or the whole province. Naturally they can occupy only a minor place among the various forest statistics collected. In most cases there is no trained entomologist on the survey party and therefore entomological observations should not require much knowledge of insects. With this in mind we have devised an entomological form now used in forest linear survey by the Quebec Forest Service. This requires only the minimum information which, we believe, should be recorded in the course of forest survey work.

The front of the form, contains general details regarding the location and size of the sample plot. It also includes such information as the age, type, density, volume, and composition of the stand. All information, except the volume figures, is recorded on the form while in the field but is later calculated at the office from the tally sheet.

The notes entered on the back of the form (fig. 2.) are included under three headings: living trees, dead trees and population study.

Living Trees.—The living trees, according to the percentage of defoliation or the percentage of the trunk infested by bark-beetles are grouped into five classes, corresponding quite closely to those adopted by Tragardh ('39), for bark-beetle studies. These are probably the most satisfactory used. The first and fifth classes, which represent the none and total infestation, being readily separated from the others, we have only three classes left: the less than half; half; and more than half of the trunk infested or crown defoliated.

The defoliation is estimated ocularly in percentage of the whole stand. Thus, considering the spruce only, we may have 25% of the stand in the

Tragardh I. and Butovitsch C., 1939. Some forest Entomological Methods and Conception. Bull. Ent. Res. 29: 191-210.

0-10% class, while 60% will fall in the 10-40% class, and the balance i.e. 15%, will come in the 40-60% class.

Living trees infested by bark-beetles are tallied individually in the square to which they belong but without taking into account the diameter. It is assumed that these trees will have the average stand diameter. By so doing we are on the conservative side because the bark-beetle species with which we are mainly concerned in the province is *Dendroctonus piceaperda.* Hopk., which favours trees of 7 inches in diameter and up. Moreover a *Dendroctonus* infested tree will remain living for a relatively short period of time and the number of living trees infested by these species will be much lower than by defoliators. In fact, a tree, even lightly attacked in June by *Dendroctonus* may, for practical purposes, be classified as dead in August. The observer, then, will only have to mention in the space reserved for remarks the year of attack or death. That is why the same square is used for defoliators or bark-beetles, and, if both cases happen in the same plot, the perecentage of defoliation is inserted in the upperpart of the square while the number of living trees attacked by bark-beetles are noted underneath.

Dead trees.—The diameter of every dead tree is calipered and noted (right side of the back page). Whether the tree is killed by a bark-beetle or a defoliator is indicated by the sign plus (†) or minus (-), placed next to the dot in the proper diameter square. When known, the name of the insect responsible for the death of the tree is entered in the remarks reserved to dead trees. The total number of dead trees and their cubic contents will be calculated and noted at the officce.

Population Studies.—The headings under studies of population are very general so as to apply to various injurious insects and give more latitude to the observer depending on his competency and the time at his disposal. Population studies are very important and if the observer has only a rudimentary knowledge of entomology, the sample, if preserved in alcohol or sent living to the entomological laboratory, will prove the identity of the injurious species present in the district.

According to the period of the year and the insect concerned, the population study will consist of: an egg sample as for the forest tent caterpillar, the area examined being 5 or 6 branches; a larval or adult sample with a 4 inch tree as area examined for the spruce sawfly, and 10 x 18 inches of bark for *Dendroctonus;* a cocoon sample where one square foot or more of moss and litter are looked over.

Front of the form in use for entomological observations in Forest Survey.

FOREST ENTOMOLOGY
Place of Sampling
Regional Inventory

Line No. *4 D. West* Place No.............8
Direction of Line *273 deg.* Chain *320* Locality *Canton Jette*
County *Matapedia* Basin *Metis* River *Humqui* Range *59 feet*
Acre *0.25* Situation *5 deg. N.E.* Altitude

Type and age *Coniferous 90 years*

		Vol. P.C.	*%*
Proportion of species - - -	*Spruce*	*591.6*	*19*
	Balsam	*2310.4*	*74*
	Others	*205.2*	*7*

Cubic feet per acre *3107.2*
Density *0.7*
Observer *Rolland Cusson* .. ..Date *16 July, 1938*
Verified *T. Landry* Date *17 July, 1938*

Back of the form in use for Entomological Observation in Forest Survey.

LIVE TREES

% Defoliation or % of trunk infested

SPECIES	0-10	10-40	40-60	60-90	90-x
SPRUCE	*25* :	*60* : :	*15* .		
BALSAM	*100*				
OTHERS	*100*				

Remarks—*Trunk infested by Dendroctonus. Defoliation by D. Polytomum*

DEAD TREES

Amount per acre	Borers	Defoliators	Balsam	Other Species
1. Number of branches	*6*	-	-	-
2. Cubic feet	*110*			

Remarks—*Spruce killed by Dendroctonus*

STUDY OF POPULATION

Stage	Species	Superficial examination	Number
Eggs			
Larva	*White spruce*	*tree 4" diam.*	*232*
Cocoon	*White spruce*	*1' x 1'*	*47*

Remarks—*Larvae of D. polytomum and 5 others placed in alcohol*

DEAD TREES*

D.H.P.	Spruce	Balsam	Others
4			
5			
6			
7			
8	- †		
9			
10	- †		
11	- †		
12	- †		
13			
14			
15	- †		
16			
17			
18			
19			
20			
21			
22			

*
† = Trees killed by borers.
\- = Trees killed by defoliation.

Analysis of Insect Sample

It has already been mentioned that information concerned with forest insects activity is not only obtained by survey parties but also samples sent in by the fire-rangers. Details of this project have already been published by the writer (Gobeil '39). It is only necessary to mention here that twice a month some 500 fire-rangers stationed all over the province collect larval samples which are shipped alive to our laboratory at Duchesnay, Portneuf County.

Larval samples are assuredly the most reliable source of data to be obtained from fire-rangers. Cocoon samples may sometimes prove valuable but they require much more attention and time on the part of the ranger. Examination of a 2 ft. x 2 ft. sample takes from one to two hours. Besides, even if the work is done by an entomologist ,there will be a certain percentage overlooked. This percentage will tend to increase should the examination be made rapidly or by an untrained man. Our experience in 1938 has indeed shown that, although the work is carried on under the supervision of an inspector over 50% of the cocoons may sometimes remain unnoticed. On the other hand, larval samples collected at regular intervals, with sheets of standard size, on trees of uniform diameter, will give quite accurate population records at least for certain insects such as the sawflies. The task is more or less mechanical, a tree of 4 inches diameter being jarred with an axe and all the population collected and placed in the shipping box. It is true that even with a collecting sheet of 10 square feet, such as the one devised by the Quebec Entomological Service, some of the larvae will fall outside of it, but here the error is uniform and the proper correction can be applied. This is not the case with cocoon samples because of the great variation in the accuracy and uniformity of such records.

Through regular larval collections made during the same season, an entomologist can determine for a certain species the number of larvae that can be expected for each of the five defoliation classes, mentioned in Table 1. From the data thus obtained, the number of larvae collected by the fire-rangers in any location may be expressed in terms of defoliation. This year we have tentatively adopted for the European Spruce Sawfly, *Diprion polytomum* Hartig, the standard given in Table 1. column 4.

Table 1

Classes of Infestation for Defoliators

DEFOLIATION		*Denomination	No. of larvae for D. *polytomum*	Symbols for Mapping
%	Class			
0-10	0%	None	1-50	○
10-40	-50%	Light	50-200	⊖
40-60	50%	Medium	200-500	⊕
60-90	+50%	Heavy	500 and +	◒
90-100	Total	Complete	- than 200	●

*Intended for *Diprion polytomum only.*

Gobeil, A. R. (1939)—Les Insectes forestiers du Quebec en 1938. Dept. Lands and Forests, Ent. Serv. Bull., 3: 1-48.

Corresponding to the second, third and fourth classes of defoliation we have used in Table 1, column 3, the denominations light, medium and heavy which are commonly employed. Thus expressed, the denominations are expected to hold true with the corresponding classes for the European Spruce Sawfly only, and the fire-rangers are instructed not to designate the degree of infestation by these terms which may lead to confusion due to the fact they need a definition for almost every different species concerned. For instance, in a Forest Tent caterpillar outbreak, one could hardly call an infestation heavy when the trees have only 60-90% of the leaves stripped, while such a percentage of defoliation for the European Spruce sawfly would indicate a severe or heavy infestation. But, if the defoliation is expressed in percentage such as in column 2, table 1, there is less room for individual variation and error because we are dealing with definite figures instead of terms which might be interpreted differently. The entomologist on reception of the report may, if advisable, make the proper adjustments and designate the infestation by the terms, light, medium and heavy.

Permanent Sample Plots

The equipment supplied to each of the fire-rangers engaged in our Forest insect survey, as well as the written and verbal instructions given by our field instructors enable the collector to take very reliable insect samples. Occasionally some of them will even record valuable data on the composition and age of the stand, nature of the damage and intensity of the infestation. This, however is not compulsory. At least for the present we believe that it is preferable to leave it optional so that the maximum quantity of standardized information may be obtained.

In order to get the greatest benefit possible from the observations made by the rangers it has been decided to supplement these next summer with more detailed and technical data collected by trained forest entomologists. For this purpose about one third of the three hundred or more representative permanent sample plots already established in the province either by the Quebec Forest Service or forest companies, will be used for entomological observations..

Besides the information usually taken on sample plots, each tree will be carefully examined from the entomological angle. Larval as well as cocoon samples will be taken and the entomologist will correlate the degree of defoliation with the population on the tree. Later on, the conversion factor thus obtained for different species on trees of different sizes in different regions, could be applied to all the samples sent in by the rangers of those different regions.

We hope to make of those permanent sample plots basal stations with which will be tied up all the observations made by the rangers in connection with the forest insect survey.

Conclusion

This paper gives a very brief description of the methods actually employed by the Quebec Entomological Service of the Department of Lands and Forests to estimate forest insect damage, and get continuous information on forest activities. We are sure that the methods can be greatly improved and we would be grateful to have advice and comments from those who have had experience in this field. As it is, however, we feel we have made great progress towards a better knowledge of the forest insects of Quebec and consequently towards means of control.

SOME POSSIBILITIES IN CONTROL OF THE PINE SAWYER BEETLE BY CHEMICAL METHODS

By P. M. MORLEY

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Fresh or recently cut logs of pine, spruce and other coniferous trees are the natural breeding ground of wood-boring beetles of the families Cerambycidae and Buprestidae. The adults normally lay their eggs in spring and early summer in crevices in the bark or in excavations made with their mandibles. The developing larvae first tunnel on the wood surface and later bore into the wood itself. In most species, they overwinter here in shallow pupal chambers, emerging as adults the following spring.

Some species, notably the pine sawyer beetles, *Monochamus* spp., require two or three seasons to complete their larval development. The larvae of this group begin to tunnel into the wood from four to six weeks after hatching and can cause quite a serious depreciation of the grade of lumber by the end of the summer, thus justifying the use of control measures.

The problem becomes particularly acute when, as often happens, an early breakup in the spring results in many skidways being left in the bush over the summer months. Various methods of control have been proposed and some of these have proved to be very effective. Both barking of logs and flotation in water will prevent oviposition but require further rehandling and redecking of logs, materially increasing the cost of operations. Some method is obviously required which can protect the logs *in situ* and the possibility of employing chemical sprays for this purpose would merit consideration.

MATERIALS EMPLOYED

There are two methods of approach to this problem. One is to find a chemical which can be applied either at the same time as the logs are cut or in early spring before the appearance of the adult beetles. Such a chemical should act either as a repellent or as a stomach insecticide or better still, have the combined function, i.e. make the logs unattractive to the adult beetles and also kill the latter during the process of egg laying. Again, since *Monochamus* has a long period of flight and oviposition, such a spray must either be inherently effective as to adhesive properties for some time (two months at least) or must be combined with some sticker which will achieve this purpose.

The second method of approach is in the use of some contact insecticide, which will penetrate the bark and kill the young larvae before they enter their more destructive stage. Time of application is important here; this must be timed late enough so that the major part of the probable infestation of the log has taken place and early enough so that damage to the log is as light as possible. Further, since many logs of the larger diameters have a thick bark, good penetration is a prerequisite for such an insecticide.

a. *Repellents and Stomach Insecticides.*—A long list of materials was tested during the first season either alone or in combination with each other. These included arsenicals, fluorides and fluosilicates, various tar derivatives, lime, sulphur, etc. Where possible, these were tested both as dusts and as sprays. The great majority of the logs treated failed to show any results from spraying, being as heavily infested

as the checks, but a combination of lime sulphur and a soluble arsenical, sodium arsenite, seemed to show some promise and merited further trials. Consequently, during the past season, work was concentrated on these sprays, lime sulphur, lime sulphur-sodium arsenite combination in varying proportions, lime sulphur-calcium arsenate-iron sulphate (modification of Kelsall's formula), these alone or employed with stickers. All except the lime sulphur-sodium arsenite treated logs were heavily infested with larvae when examined ten weeks later. These latter were very slightly infested (an average of two larvae per log compared to 27 in the checks) and the few larvae present were so immature that it was indicated that this attack was of only recent occurrence. No attempt has yet been made to test this on a commercial basis; further work is still to be done on testing for the most suitable proportions of the constituents and evaluating the effect of stickers.

b. *Contact Insecticides.*—Previous work by Salman (1938) indicated that various penetrating oils such as fuel oil, stove oil and crankcase oil used in combination with tar derivatives (creosote, coal tar acid oil) or simple organic compounds (naphthalene, PDB) should be tested. During the first season, Salman's formulae were the only ones tested and the results obtained were so promising that it was decided to test two of them, fuel oil-naphthalene and fuel oil-crankcase oil-creosote on a commercial scale the following summer (Morley, 1939). The past season, these oils were again tested and in addition other combinations which included orthodichlorbenzene, penthachlorphenol and two proprietaries "Permatol" and "M.B.C. 24". Many of these materials while effective are also too expensive for direct use, one method of reduction of cost per gallon being dilution with fuel oil. Thus, one part "M.B.C. 24" to seven parts fuel oil is almost as effective as the straight spray.

A definite relation exists between the atmospheric temperature at time of spraying and larval kill obtained. The percentage mortality being higher on hot days.

Method of Application

a. *Experimental Work.*—For the number of individual treatments required, the cutting of separate pine skidways would obviously be both impossibly expensive and also unnecessary. Small piles, each containing fifteen logs four feet long were used, these with average diameter six inches. Each pile was sprayed with two gallons of the mixture, using a standard knapsack sprayer for the purpose. The spray solution was directed particularly on the sides and undersides of the logs and at the ends since experience has shown that it is at these points that *Monochamus* adults concentrate their attack. Later, examination consisted in removing the bark from three logs in each pile and taking a count of living and dead larvae, and the number of each on the wood surface, entering the wood, and in the wood. This latter was an arbitrary classification based on practical considerations rather than on different larval instars.

b. *Commercial Tests.*—Some penetrating oils mentioned above were tested on a commercial scale on the limits of the Luceville Lumber Company both as a check on the results obtained from the experimental series and also to test methods of applying the oils. A standard Johnson-Tremblay fire pump loaned by the company and equipped with a reducer nozzle was used for this work, the logs being sprayed at the rate of six to seven gal-

lons per minute. Cost of spraying averaged around twenty cents per gallon or 4½ cents for an individual 16 ft. long. Larval mortality obtained was close to that given by the experimental work. Of chief interest was the demonstration that standard bush fire-fighting equipment could be used for this purpose, a very important factor if spraying for *Monochamus* control is ever to be undertaken on a large scale.

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THE CANADIAN FOREST INSECT SURVEY IN 1939

By A. W. A. BROWN

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The co-operative project between the forest services and forest industries with the Division of Entomology, known as the Forest Insect Survey, has again shown a remarkable growth in 1939. With over two thousand men co-operating in the field, 8,310 samples have been taken, as compared with 5,117 in 1938 and 512 in 1936, the first year. Of these samples, 3,225 were handled at Ottawa, Ont., 1,234 at Fredericton, N.B., 942 at Vernon, B.C., and 2,909 by the Quebec Entomological Service at Duchesnay, Que.

The range covered by the survey (Fig. 1) now includes all provinces from the Atlantic to the Pacific, including also Newfoundland and Labrador, and extending northwestward to the Arctic Circle. The bulk of the samples was taken in the commercially valuable stands in eastern Canada, but increasing attention is being paid to the less accessible but vast areas north of the prairies, up to the margin of tree growth. In this connection we were fortunate, in 1939, in having the co-operation of the Hudson's Bay Company, from which many outstanding distribution records have been obtained.

The most important development in the project's organization has been an arrangement whereby the Quebec Forest Entomological Service has taken over survey work for the Protective Service and forest protective associations in the central and eastern part of the province of Quebec. As with the other units, all information obtained is digested, correlated and recorded at Ottawa, each unit also centralizing and recording all data for its particular region.

Results of the survey in 1939 consist of detailed data on larval forms, biology, parasitism, distribution, and host-trees of the many hundreds of insect species received and reared. However, this paper deals with only one phase, that of the annual status of infestations. This information has been obtained not only from survey reports and survey co-operators, but more especially from forest entomologists throughout the various regions

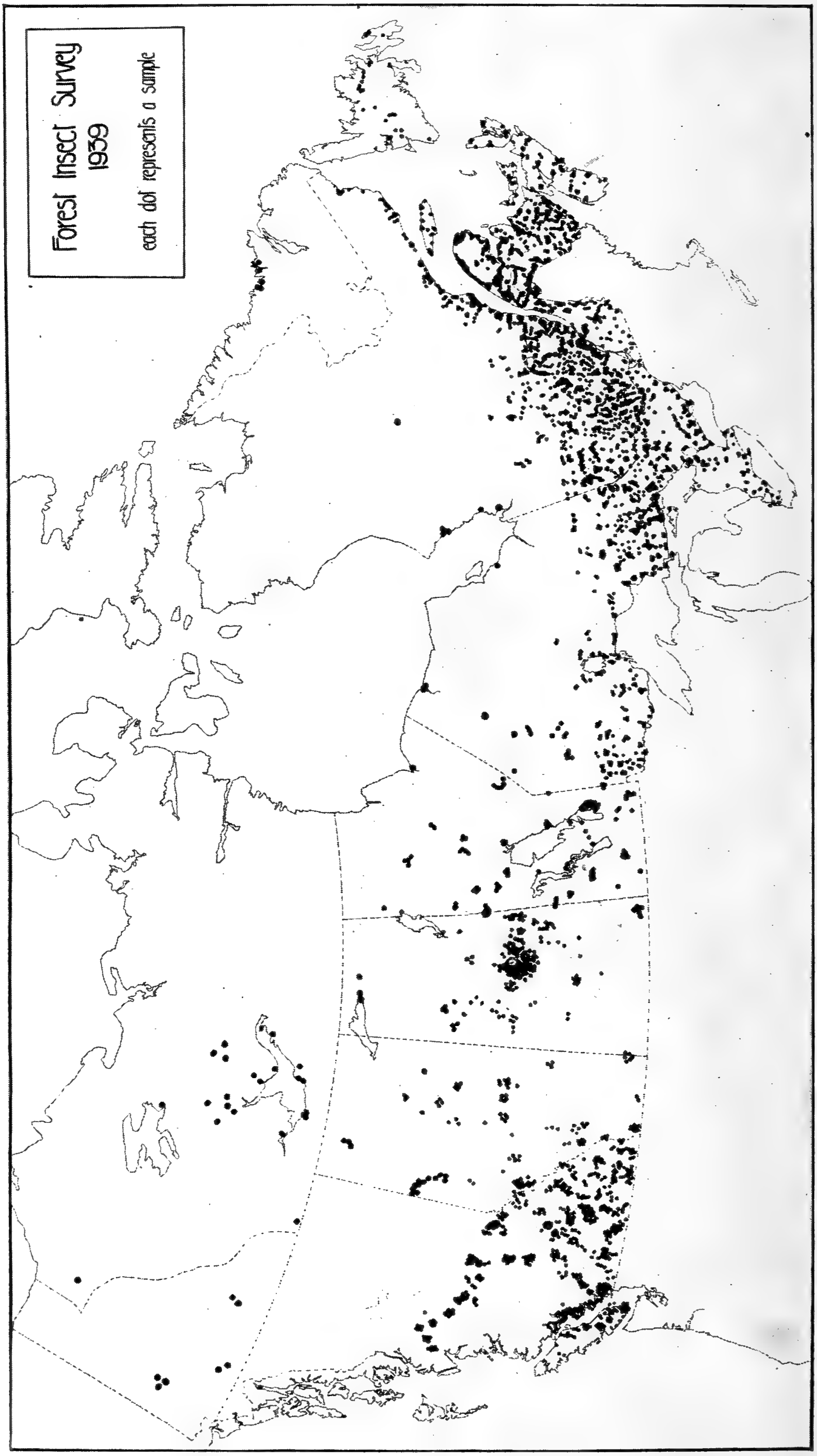

Fig. 1. Location of all samples taken for the Forest Insect Survey in 1939

of Canada. It is due to their observations that the clues offered by the survey routine are followed up, and a final accurate picture thus obtained.*

The principal forest insects of the year were the spruce sawfly, the spruce budworm, the jack pine budworm, the larch sawfly, and the forest tent caterpillar. The summer was characterized, especially in eastern Canada, by a late spring with persistence of snow, followed by a cool May and June. This was compensated by mean temperatures above normal in July and August, with a normal September. Precipitation was above normal in July and August, the Maritime Provinces however experiencing a drier August. The different species are now considered in detail, a certain taxonomic order being observed.

Hymenoptera

The European spruce sawfly, *Gilpinia polytoma* Htg., has shown only slight changes in the area of known infestation this year. A few new records have been obtained from the counties of Papineau, Maskinonge and Labelle in Quebec, and the eastern boundary of the southern Ontario infestation extended to Marmora (Fig. 2). In spite of intensive collecting, no records were obtained in the Gatineau valley, nor in the area centering on Algonquin Park. In the east, its presence has been established for the first time on Anticosti Island, and extensions eastward have been found in Prince Edward Island and Cape Breton Island. Final population intensity north and west of the St. Lawrence, in spite of a late summer, showed a noticeable increase north and east of Quebec city, while a decrease was recorded in North-western Quebec.

The nursery pine sawfly, *Diprion frutetorum* Htg., has yielded no new records, but the infestation on Scots pine at St. Catharines, Ont., has shown a slight increase.

Two larvae and 15 cocoons of *Neodiprion sertifer* Geoff. were taken at Windsor, Ont.; this is the first Canadian record, it having been known for some years in the state of Michigan.

Leconte's sawfly, *Neodiprion lecontei* Fitch, caused scattered infestations along the St. Lawrence Valley from Port Hope, Ont., to Rimouski, Que. Apart from heavy attacks at Thessalon and in the Victoria County Forest, Ont., this insect is still less in evidence than for an average year. Abbott's pine sawfly, *Neodiprion pinetum* Nort., defoliated white pine at Thessalon, Dwight, and Markdale, Ont., and in counties Montcalm and Rimouski, Que.

The balsam fir sawfly, *Neodiprion abietis* Harr., occurred on balsam and spruce throughout Canada, in the east often in large numbers. A belt of infestation on balsam bordered the east shore of Lake Superior and the North Channel of Lake Huron, then recurring from Ottawa down the river to Hawkesbury, Ont. Considerable defoliation was observed near the Sault, Garden River, Thessalon, Buckingham, Morrisburg and Omemee in Ontario, and Ile Madame, N.S.

* In addition to that obtained by H. S. Fleming and D. N. Smith, especially valuable information has been supplied by Dr. C. E. Atwood, R. E. Balch, Dr. L. Daviault, G. H. Hammond, L. S. Hawboldt, G. R. Hopping, Robert Lambert, H. B. Leech and H. A. Richmond.

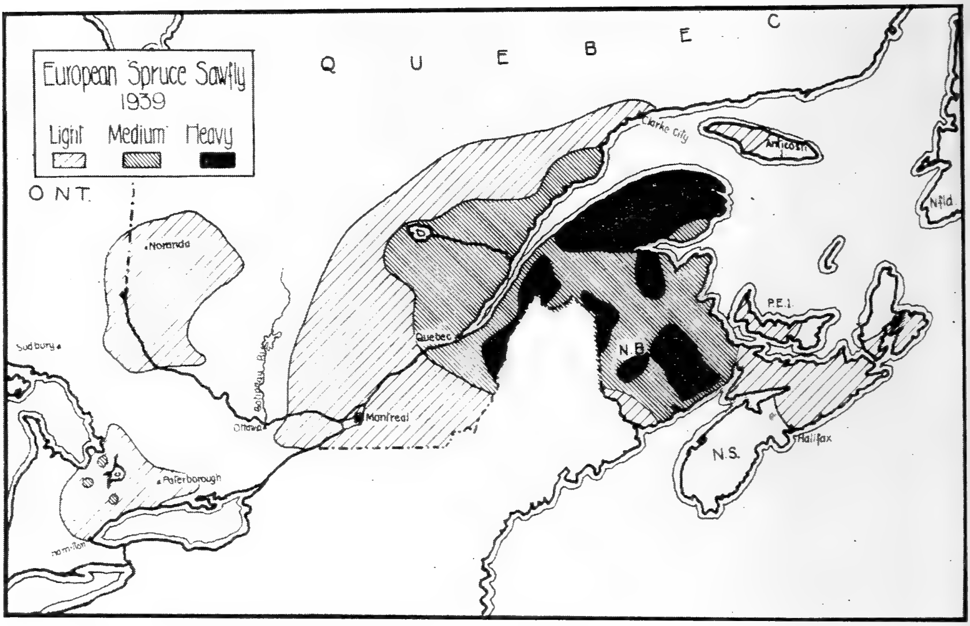

Fig. 2 Known distribution and infestation status of the European Spuce Sawfly

The red pine sawfly (*Neodiprion* sp. undescr.) has become extremely abundant on red pine in Co. Temiscamingue, Que. and around Biscotasing, Ont., and throughout northwestern Ontario from Quetico Park west into southeastern Manitoba; defoliation may be as much as 10-25 per cent. The form on jack pine, probably the same species, has been very active throughout eastern Algoma, areas near Biscotasing and Chapleau often experiencing 50% defoliation; jack pine was also stripped at Minaki in northwestern Ontario. This species has been evident only in the last three years, steadily increasing to 1939.

The red-leafed jack pine sawfly, *Neodiprion dubiosus* Schedl, is even less conspicuous than in 1938. Small infestations have been spotted at Kirk and Glendale, Ont., and L'Ascension, Que., while it is abundant east of Prince Albert, Sask. However, in most areas it has become quite rare. The same may well be said of Swaine's pine sawfly, *Neodiprion swainei* Midd. The black-headed jack pine sawfly, *Neodiprion nanulus* Schedl, caused very heavy local infestations at Spencerville, Ont., Quyon, Que., and Farlane in northwestern Ontario.

The hemlock sawfly, *Neodiprion tsugae* Midd., has decreased in numbers at Trinity Valley, B.C., scene of an outbreak last year. The lodgepole sawfly, *Neodiprion* sp., occurred throughout British Columbia and was locally abundant at Trinity Valley.

The arbor-vitae sawfly, *Monoctenus juniperinus* MacG., has been found throughout southeastern Ontario, northward to Timmins and eastward to Co. Rimouski, Que. This species was plentiful on a white cedar hedge at Epsanola, Ont.

The birch sawfly, *Arge pectoralis* Leach, has frequently damaged birch in eastern Ontario and western Quebec; Brent, Arnprior, Bells Corners, Spencerville, Roebuck, Ont., and Danford Lake,, St. Michel

des Saints, St. Felix Dalquier, St. Valerien, Que., being the localities principally concerned. The willow arge, *Arge clavicornis* Fab., caused a severe local infestation at Timmins, Ont.

The birch leaf-miner, *Fenusa pumila* Klug, has been responsible for moderate infestations with local outbreaks in the lower Nashwaak drainage area, N.B., and Grenville county, Ont.

The European poplar sawfly, *Trichiocampus viminalis* Fall., was found as far northwest as Timmins, Ont., 18 larvae being taken on willow.

The alder sawfly, *Hemichroa crocea* Four., heavily infested alder in the Harry's Brook region, near Cornerbrook, Nfld.

Marlatt's larch sawfly, *Anoplonyx laricis* Marl., was common throughout eastern Canada, abundant in Co. Berthier, and in moderate infestation at St. Michel des Saints, Que.

The larch sawfly, *Pristiphora erichsonii* Htg., has decreased in some regions and increased in others (Fig. 3). The infestation along the northern transcontinental railroad in Ontario and Quebec continues to decline from the west eastwards, and trees heavily infested in 1937 and 1938 are now recovering. Further south, however, in Algoma and Nipissing, the infestation is heavy. Westward, in Saskatchewan, Manitoba, and northwestern Ontario, population is generally light. The greater part of Quebec north of the St. Lawrence is moderately infested. While tamarack in northern New Brunswick is scarcely attacked, stands in the south, notably in Charlotte Co., show heavy outbreaks. Moderate infestations were found in northwestern Nova Scotia, while a heavy attack was reported from eastern Newfoundland. Light infestations occur the length of the North Shore and in Labrador, while reports of moderate outbreaks come from Severn, on Hudson Bay, and from Hopedale, Lab.

The larch sawfly infestation in the Fernie-Cranbrook-Nelson area of southeastern British Columbia continues to be serious, chiefly in the valleys of the Kootenay River and its tributaries. This year it has extended westward to the north end of Slocan Lake; most important concentrations centre on Kootenay Lake, Kitchener and Moyie Lake.

The mountain ash sawfly, *Pristiphora geniculata* Htg., is becoming more serious in the St. Lawrence valley of Quebec. However, it was less abundant than in 1938 in the Ottawa-Spencerville region, nor was it heavy in the Fredericton area. Damage in spots was reported from Charlotte Co., N.B., and Annapolis Co., N.S.

The yellow-headed spruce sawfly, *Pikonema alaskensis* Roh., continues to give scattered records of heavy defoliation on open-grown spruce, from Gaspe to Jasper. It is difficult to detect any difference in its status from year to year; nevertheless the "centre of gravity" this year would appear to be in Quebec. The green-headed spruce sawfly, *Pikonema dimmockii* Cress., continues as an inconspicuous element of the spruce fauna from the Atlantic to the Pacific and north to Mackenzie district, N.W.T.

The yellow-spotted willow slug, *Pteronidea ventralis* Say, proved very injurious to planted poplars and willows at Berthierville, Que., the second generation being responsible. Two willows were completely defoliated at Brandon, Man. The locust sawfly, *Pteronidea trilineata* Nort, severely defoliated one honey locust at Orr Lake, Ont.

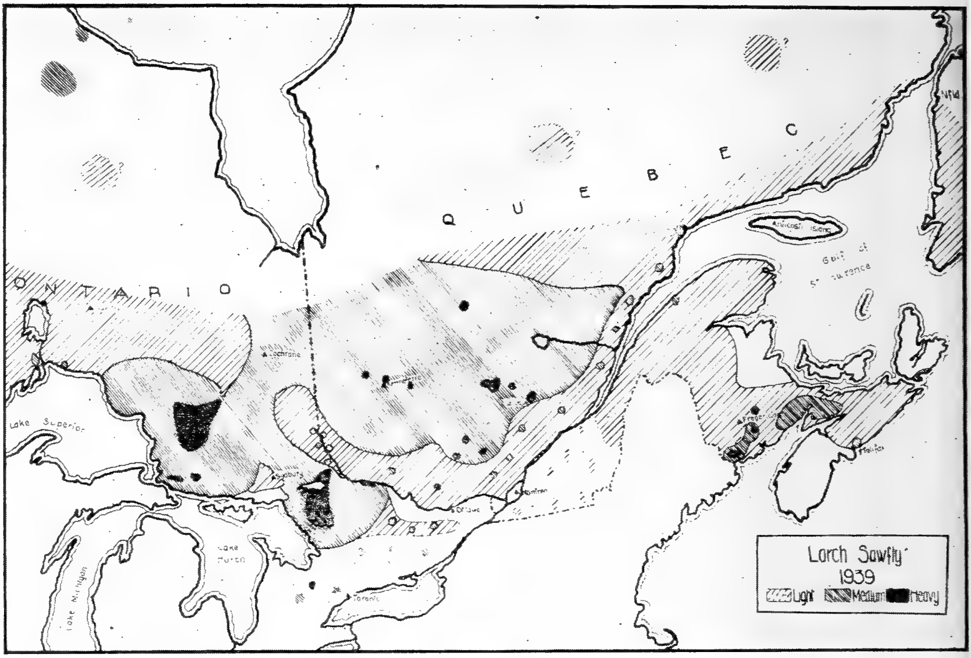

Fig. 3 Infestation status of the Larch Sawfly in Eastern Canada.

Poplar leaf-folding sawfly, *Pontania* sp. or spp., heavily infested aspen poplar at Timagami, Biscotasing and Sand Lake in northeastern Ontario. Leaf-roll on balsam poplar, associated with aphids, was noted from North Bay to Sault Ste-Marie, centering around Thessalon, Ont.

The black-headed birch sawfly, *Croesus latitarsus* Nort., caused complete defoliation of a stand of birch near Arichat, Cape Breton Island.

Pine web-spinning sawflies, *Cephalcia* spp., besides being frequent on spruce, have occurred in destructive numbers on red pine, notably at Fort Frances, Ont., and Blanche, Brennan Lake and near Berthierville, Que.

Lepidoptera

The spiny elm caterpillar, *Nymphalis antiopa* L., was reported defoliating aspen foliage at Skead, near Sudbury, Ont., shortly after it had suffered a moderate infestation of forest tent caterpillar.

The cecropia moth, *Platysamia cecropia* L., has caused slight defoliation of Manitoba maple over an area 100 miles long in southern Saskatchewan (from Bengough to Hodgeville) ; the population level is very much lower, however, than during the destructive outbreak of 1931-1934.

The green-striped maple worm, *Anisota rubicunda* Fab., has shown a sudden increase in the southern Algoma district of Ontario in 1939 (Fig. 7). Heavy defoliation of red and sugar maple is concentrated in three townships north and west of Blind River, and areas of moderate to heavy defoliation were found from Espanola to Sault Ste. Marie, and as far north as Metagama; the extensive areas of hard maple north and west of

the Sault have apparently not yet been attacked. Two heavy infestations were reported in Pontiac County, Que.,—at Beach Grove and Otter Lake, while there were concentrations on the Vivian and Durham Forests, Ont.

The rosy-striped oak worm, *Anisota virginiensis* Dru., partially to completely defoliated oak, also maple and other hardwoods, over an area of five square miles on Young Island in the Ottawa River near Fort Coulonge, Que. (Fig. 7.). This island had been attacked in the same manner in 1938.

The imperial moth, *Eacles imperialis* Dru., was especially abundant on white pine at Campbellford, Ont.

The sycamore tussock moth. *Halisidota harrisii* Walsh is causing a general infestation on sycamore in Essex county, Ont., damage being extreme from Essex to Ruthven.

The fall webworm, *Hyphantria cunea* Dru., has become conspicuous on hedge and roadside trees in almost all parts of the country, attacking nearly all hardwoods with the notable exception of maple. Although the 1938 infestation along the St. Lawrence River in the Montreal region has subsided, and infestation in the Eastern Townships of Quebec is light, the remainder of the province is moderately infested, down to Rimouski and even New Carlisle in Gaspe South. In New Brunswick, the webworm is especially noticeable south of Grand Lake, being light in Charlotte and St. John counties; infestation is moderate in Prince Edward Island (especially on apple) and light in Nova Scotia. In Ontario it was found as far north as Cochrane and Hearst; though light in the Temiskaming-Sudbury area, it was heavier in the region of the Sault, and there was a moderate infestation at Batchawana on Lake Superior. A light outbreak covered the central and eastern parts of Old Ontario, moderate and even heavy attack being found in Grenville, Frontenac and Victoria counties. It was scarce in southwestern Ontario, with the exception of Point Pelee, where the infestation was 40% over the normal yearly level. Occasional infestations were reported from southeastern Saskatchewan, and nests were numerous on western alder in the region of New Westminster, B.C.

The chameleon cutworm, *Anomogyna elimata* Gn., was reported in enormous numbers and defoliating spruce at Nitchequon, in the interior of far northern Quebec, 200 miles north of Lake Mistassini.

The armyworm, *Leucania unipuncta* Haw., has given no records from northern Ontario and Quebec, as it did so abundantly in 1938.

The fir harlequin, *Elaphria versicolor* Grt., noticeably defoliated branches of balsam at East Angus in southern Quebec.

The black walnut caterpillar, *Datana integerrima* G. and R., continued to be serious in southwestern Ontario, as in the past six years, especially in the Point Pelee region; northern limits of the heavy infestation were at Sarnia and Barrie.

The rusty tussock moth *Notolophus antiqua* L., was a common faunal element of spruce and other trees in southern regions. The western form, var. *badia* Hy. Edw., heavily attacked two blue spruce at Vernon, B.C.

The Douglas fir tussock moth, *Hemerocampa pseudotsugata* McD., is causing an infestation, mainly of medium intensity, over an area 30 miles long by 15 miles wide, northeast of Okanagan Lake, B.C. The Lavington outbreak has considerably increased since 1938, while other foci are near Armstrong, Vernon and Okanagan Landing. Medium infestation is reported from the North Thompson valley.

The grey spruce tussock moth, *Olene plagiata* Wlk., was common on spruce in eastern Canada, being found also on white pine, balsam and tamarack.

The satin moth, *Stilpnotia salicis* L., is causing heavy infestations in Nova Scotia, central and western Prince county, P.E.I., in spots in Westmoreland and Kings counties, N.B. and in the outlying area near West Bathurst, N.B. The newly discovered infestation near Quebec City extends from Beauport to Cap Rouge, while the insect is established on the Magdalen Islands and at St. Johns, Nfld.

The forest tent caterpillar, *Malacosoma disstria* Hbn., has shown a decided decrease in eastern Canada, while persisting north of the prairies. In a previous paper, written in 1938, it was suggested that this insect was approaching the end of a cycle in Ontario, but that the outbreak threatened to move down the Ottawa River to meet the eastern Ontario infestation (1). Such was found to be the case in 1939 (Fig. 4). The Nipissing infestation had largely subsided, persisting only in outlying areas to the north such as Wanapitei Lake, Kipawa Lake, and southwest of Timagami. The main body was found well down the Ottawa River in the valleys of the Madawaska and Bonnechere, becoming completely continuous with the spotty eastern Ontario infestation (some of these spots extended into Quebec). Algonquin Park was left untouched, presumably owing to its high content of tolerant hardwoods, while the western boundary of the infestation followed almost exactly around the edge of the hardwood highlands.

The extensive outbreak of northwestern Ontario has completely subsided, being represented in 1939 by only a small infestation southeast of Lake Nipigon. This marks the end of a cycle of damage first observed in the Kenora region in 1931. The situation still remains serious north of the prairies, where the infested area extends from west of Prince Albert to the Nelson River (Fig. 5). Centres of infestation were Nipawin and Hudson Bay Junction, Sask., and The Pas, Man. The last-named locality was first attacked in 1938 by an eastward extension of the Saskatchewan outbreak; this year, infestation has extended far beyond it to the northeast. In Alberta, infestation has again started around Lesser Slave Lake and on the upper reaches of the Athabaska River, and the population is building up again over a large area north and west of Edmonton.

The western tent caterpillar, *Malacosoma pluvialis* Dyar, increased in abundance in Co. Temiscamingue, and completely defoliated open-grown cherry and birch around Laniel, Que. It caused a heavy infestation this year at a number of points in Vancouver and district, and was much in evidence in the neighbourhood of Victoria, B.C.

The orchard tent caterpillar, *Malacosoma americana* Fab., so conspicuous in Old Ontario in 1938, has still been in evidence in 1939. The infestation has decreased in eastern Ontario and southern Quebec, with the

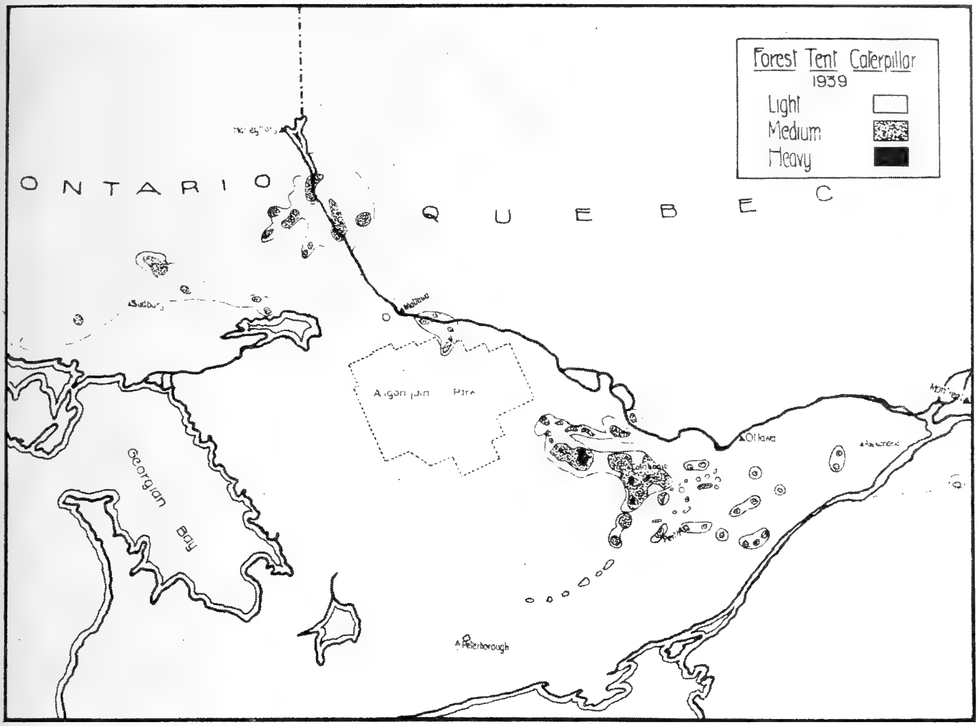

Fig. 4. Infestation status of the Forest Tent Caterpillar in Eastern Canada.

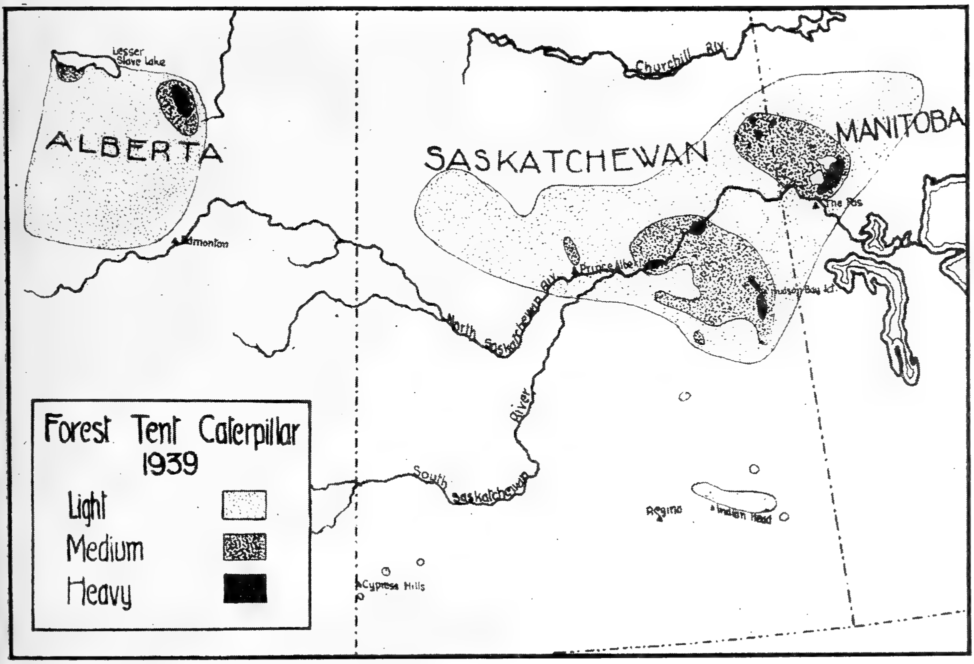

Fig. 5 Infestation status of the Forest Tent Caterpillar in Western Canada.

exception of the Hemmingford area and northern Victoria county, Ont. In southwestern Ontario ,it is still abundant, especially in Norfolk and Middlesex counties. Population in southeastern Manitoba is slightly above normal while it is in only light infestation in eastern, central and southeastern Saskatchewan. In the North Saskatchewan valley, the situation is quite different, with heavy infestations in the Cavalier-Prince area, on the Keppel Forest Reserve, and 15 miles west of Prince Albert. In the far northwest (Peace River) there is only a trace of the orchard tent caterpillar.

The fall cankerworm, *Alsophila pometaria* Harr., has greatly extended the area and intensity of its infestation in 1939. This area now includes all the prairie proper where Manitoba maple grows (Fig. 6). The greatest increase has been south and southeast of Swift Current, Sask. Defoliation has been severe, and heavy mortality is reported in some districts. The local outbreak on elm at Fredericton, N.B., artificially controlled in 1938, has completely subsided, the parasitism being increased.

The hemlock looper, *Ellopia fiscellaria* Gn., is approaching a low ebb in infestation intensity. The outbreak south of Parry Sound, Ont., is well on the wane (Fig. 7). The promised infestation on balsam 60 miles up the Outardes River, Que., did not materialize; however, a young spruce plantation was attacked at Tadoussac, Que. The outbreaks of the western hemlock looper, form *lugubrosa* Hlst., notably in the Waterton Lakes and near Nakusp, B.C., have completely subsided.

The chain-spotted geometer, *Cingilia catenaria* Dru., caused extensive defoliation of nearly all trees and shrubs in blueberry barrens northwest of Jordan Falls, Shelburne Co., N.S., and heavily attacked tamarack at Clyde River in the same county. Another heavy general infestation on many hosts was reported from Denver in Annapolis county.

Geometrid larvae again were an important element of the foliage fauna of spruce and other conifers, especially in June and again in August and September. The most common species were the green spruce looper, *Semiothisa granitata* Gn.; the grey spruce looper, *Caripeta divisata* Wlk.; the brown spruce looper, *Eupithecia palpata* Pack.; the transverse-banded looper, *Hydriomena divisaria* Wlk.; and the dotted-line looper, *Protoboarmia porcelaria* Gn., in late summer; and the false hemlock looper, *Nepytia canosaria* Wlk.; the pine measuring-worm, *Paraphia piniata* Pack; the saddled larch looper, *Ectropis crepuscularia* Schiff.; and the green larch looper, *Semiothisa sexmaculata* Pack.; in early summer.

The birch tube-maker, *Acrobasis betulella* Hlst., partially defoliated white birch near Foleyet, Ont. The alder tube-maker, *Acrobasis rubrifasciella* Pack., was in light infestation on European alder at Turkey Point, Ont.

The spruce cone worm, *Pinipestis reniculella* Grt., has caused infestations of spruce cones of considerable severity at Carp, Angus, New Liskeard, and Englehart, Ont., and Berthierville, Grand'Mere and in Saguenay Co., Que.

The Zimmerman pine tip moth, *Pinipestis zimmermani* Grt., has caused noticeable injury to planted Scots pine at South Milford, Annapolis Co., N.S.

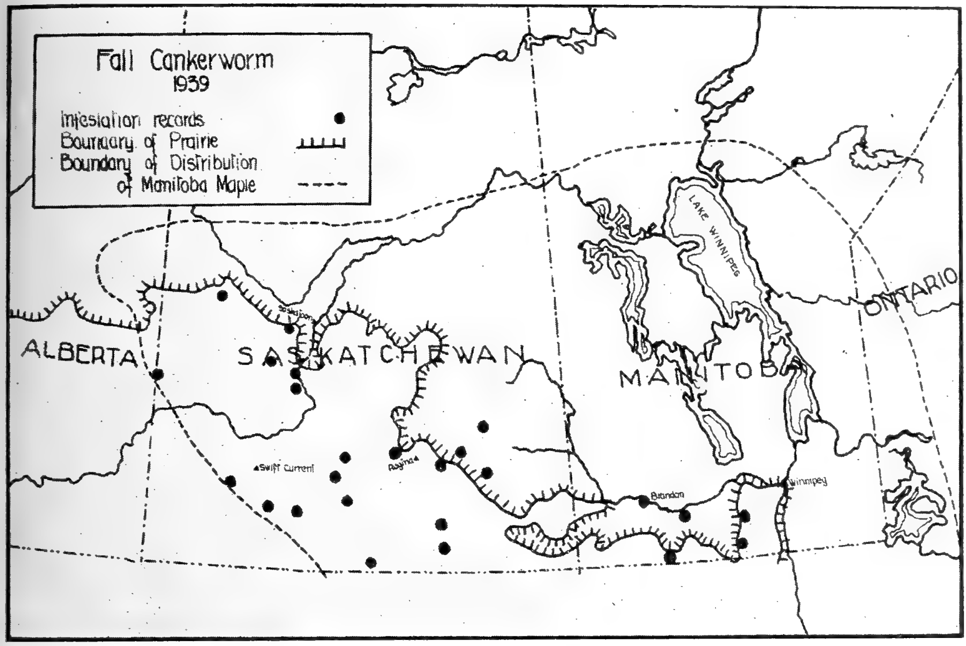

Fig. 6 Infestation status of the Fall Cankerworm on the Prairies.

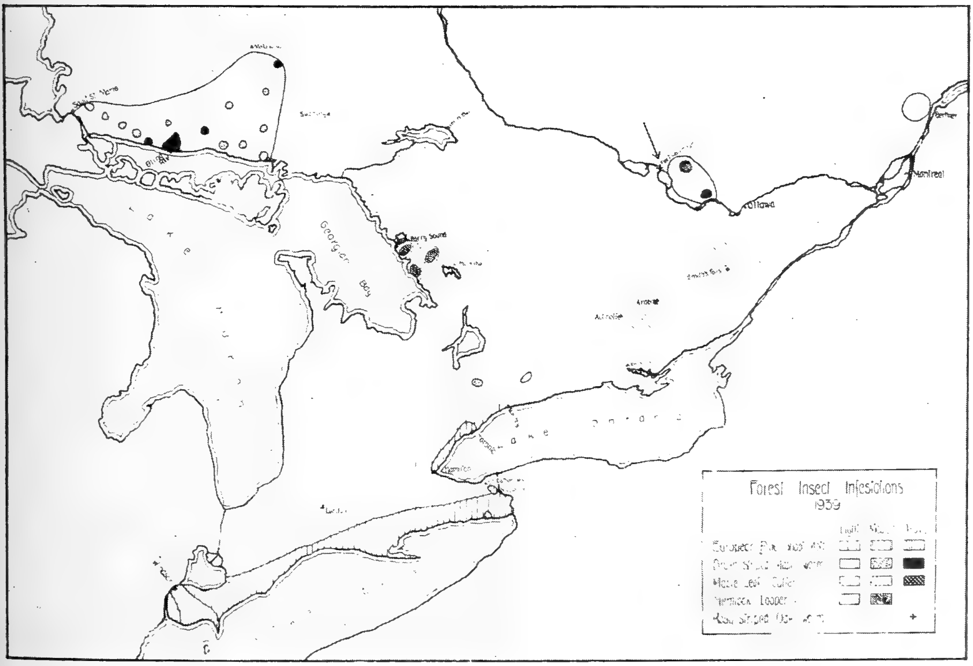

Fig. 7 Infestation status of five forest insects in Southern Ontario

The European pine shoot moth, *Rhyacionia buoliana* Schiff., continues its steady recovery from the cold winter of 1933-34. The shore of Lake Erie and that of Lake Ontario as far as Whitby are infested, the main centre being in Essex Co. (Fig. 7). The outstanding feature of this year has been the building up of heavy infestations at Niagara Falls, Ont., and St. Catharines, Ont. Population at Toronto, Ont., has increased up to a moderate intensity, while at London, on the northern boundary, the infestation is light. An infestation recently discovered at Vancouver, B.C. has been controlled artificially.

The jack pine pitch-nodule-maker, *Petrova albicapitana* Busck, has been conspicuous around Lake Abitibi, Osaquan in northwestern Ontario, and River Hebert, N.S. Smaller infestations have been noted at St. Williams and Brantford, Ont., and Riviere Croche, Que. It is probable that nearly all recent records of the pitch pine twig moth, *Petrova comstockiana* Fern., in Canada refer to the above species.

The western early aspen leaf-curler, *Exentera improbana oregonana* Wlshm., completely defoliated large patches of aspen poplar at Aweme, Man. There was a medium infestation of the hardwood leaf-roller, *Sparganothis pettitana* Rob., on sugar maple at Easton's Corners, Grenville Co., Ont.

The cherry ugly-nest tortrix, *Archips cerasivorana* Fitch, was conspicuously abundant around Hemmingford, Que., and in the Russell district, Man., though normal in the rest of the province. An infestation where whole groups of cherry were defoliated was noted extending from Matapedia to New Carlisle, Que. The oak ugly-nest tortrix, *Archips fervidana* Clem. was prevalent at Chalk River and on the Orr Lake Forest, Ont.

The spruce budworm, *Cacoecia fumiferana* Clem., has shown a sudden increase in eastern Canada in 1939. Apart from the serious outbreak in Algoma, the budworm is well distributed over north-eastern Ontario, extending further south in Old Ontario, causing light infestations in many places (e.g. Windsor, Kingston, Almonte). In the province of Quebec, which yielded no samples of budworm in 1938, there is a light infestation over Co. Temiscamingue and records come from as far southeast as counties Terrebonne, Argenteuil and Vaudreuil. A number of samples came from counties Bonaventure and Gaspe Sud, while single records were obtained in Abitibi, Charlevoix, Saguenay, Temiscouata, Rimouski, and also Madawaska, N.B. The area of heavy attack, about 3,000 square miles, centres on the Mississagi River and extends as far north as Chapleau (Fig. 8); the eastern boundary approaches that of the Gogama outbreak of 1928-32, while on the west it is nearing the hardwood highlands of the east coast of Lake Superior. Promise of further spread is most apparent in the northwest, towards and possibly even beyond Michipicoten.

West of Lake Superior the spruce budworm is rare on spruce and balsam, with some exceptions. There is a moderate infestation on spruce in the Sandilands Reserve, Man., and it is present in Prince Albert Park, Sask., where it has done damage in previous years. Further west there is a light infestation on balsam at Fortress Lake, Jasper Park, also one north of Kamloops, B.C., and an extensive infestation of long standing (since 1930) at Barkerville in the Cariboo mountains (Fig. 10); in these localities the budworm has a life-cycle involving two years.

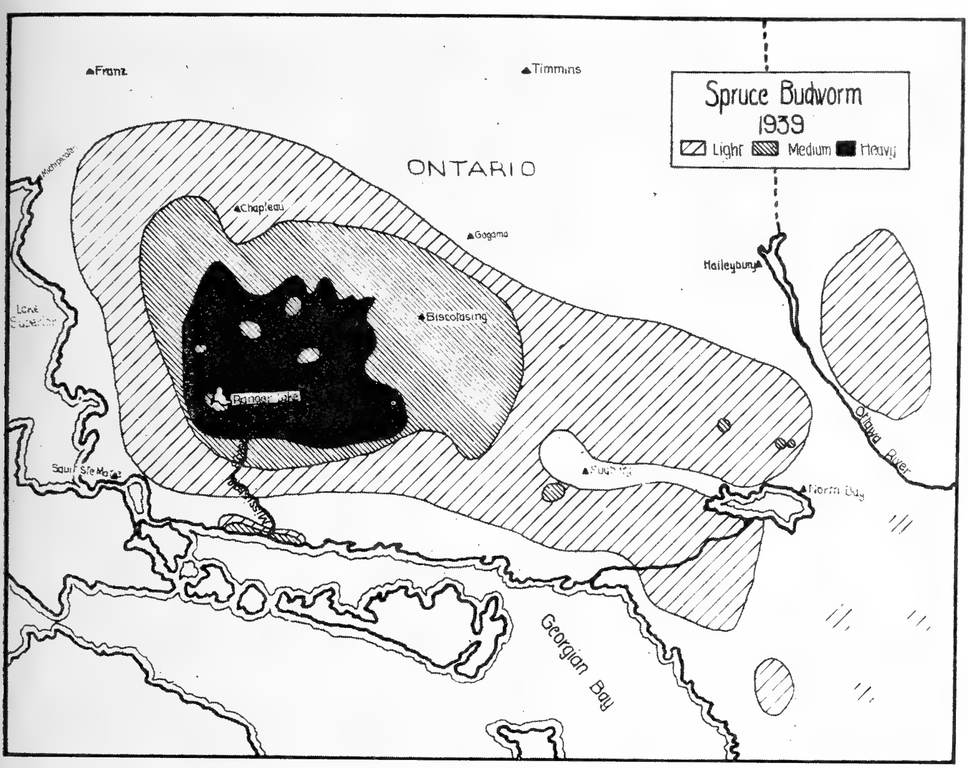

Fig. 8. Infestation status of the Spruce Budworm in Eastern Canada.

The jack pine budworm, considered a biological race of *Cacoeccia fumiferana* Clem., continues to be serious in north-western Ontario (Fig. 9). There has been a marked advance (approx. 50 miles) to the east, the spearhead of the offensive now being north of Port Arthur, Ont. The "centre of gravity" also has moved considerably eastward, since in this insect the tendency is especially marked for new infestations to become heavier than old ones. In the older areas farther west, infestation is diminishing and damage, once the outbreak has passed over, is found to be less than was anticipated.

The jack pine budworm infestation in Manitoba does not extend north of the Winnipeg River or west of Lake Winnipeg. However, there is a localized heavy infestation on the Fort a la Corne Forest, Sask., and the insect's activity is conspicuous east and south of Prince Albert. Budworm is found on hard pines in scattered areas in southeastern Ontario, the most notable cases being a serious infestation on jack pine at Midhurst, Ont. and an abundance on jack pine at Petawawa, Ont.

The fir tortrix, *Tortrix packardiana* Fern., has caused light infestation of planted Colorado blue and Engelmann spruce at Joliette and Berthier, Que., accompanied by the spruce needle-miner, *Taniva albolineana* Kft.

The black-headed budworm, *Peronea variana* Fern., has been reduced to an inconspicuous position throughout eastern Canada. The position is different in British Columbia, where a fairly extensive infestation has

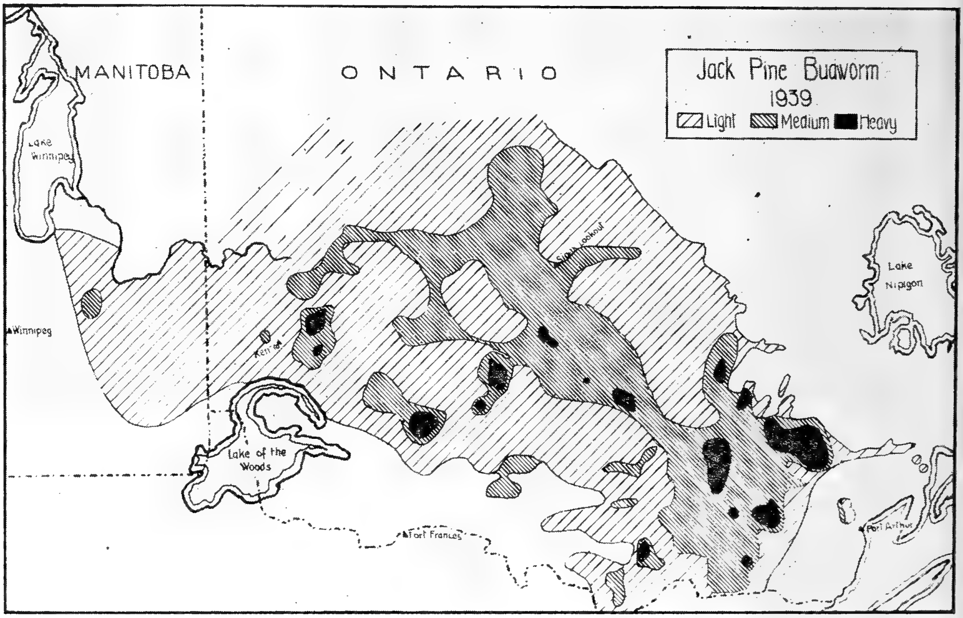

Fig. 9 Infestation status of the Jack Pine Budworm

been reported from the headwaters of the Illicillewaet River in Glacier Park and a smaller one at the south end of Kootenay Lake.

The spring oak leaf-roller, *Gelechia vernella* Murt., has caused an infestation at Turkey Point, Ont. Partial to complete defoliation of oak in western Nova Scotia early this summer may probably be attributed to this species.

The little pine shoot moth, *Exoteleia dodecella* L., continues established in Welland Co., Ont.,—the infestation at Cedar Bay having increased by one-quarter over that of 1938.

The larch case-bearer, *Coleophora laricella* Hbn., is common throughout eastern Canada. The situation in 1939 in southern Ontario and Quebec is easier, though heavy infestations have been reported from St. Williams, Simcoe, and Berthierville. In Nova Scotia, however, the insect is more numerous than for several years, and injury is noticeable in most stands of tamarack; at present there is little conspicuous injury in New Brunswick.

The birch case-bearer, *Coleophora salmani* Hein., has defoliated birch to the extent of half the foliage in areas around St. John and Welsford in southern New Brunswick.

The box elder leaf-roller, *Gracillaria negundella* Chamb., has declined in abundance at Indian Head and Saskatoon, Sask., but its numbers are persisting in areas east of Brandon, e.g. Melita and Lyleton, Man.

The lilac leaf-miner, *Gracillaria syringella* Fab., caused a great deal of damage in counties Kamouraska and Laviolette, Que., especially at Grand'Mere. Southern Ontario has suffered from its attentions also, notably at many small towns in northern York county and central Ontario county.

The birch-leaf skeletonizer, *Bucculatrix canadensisella* Chamb., after a period of little or no damage, is again attracting attention. An extensive area of damage was reported from the Riviere Chouchouan, in northern Pontiac Co., Que. It is conspicuous in west central New Brunswick, with moderate infestations along the Canaan river and around Newcastle, Grand Lake, and Washademoak Lake.

The maple leaf cutter, *Paraclemensia acerifoliella* Fitch, appears to be once more on the increase in southeastern Ontario (Fig. 7). Heavy infestation was found at Arden, and moderate ones at Merrickville, Smiths Falls and Actinolite, with light infestation at many points in this region.

Coleoptera

The bronze birch borer, *Agrilus anxius* Gory, continues to feature as a destructive forest insect. White and yellow birch in New Brunswick, especially old open stands on steep slopes, are suffering a mortality of from 5 to 75 per cent in the southern part and extending well into the centre of the province. There is also severe damage in the heavy birch stands of Madawaska county, particularly on the Green River. Northeastern New Brunswick, however, is scarcely affected, and the same is true of Nova Scotia. Damage throughout Quebec and Ontario is everywhere noticeable, but not in the same degree as in northern Manitoba and Saskatchewan, where damage is quite heavy, and particularly severe in Prince Albert National Park.

Forest leaf-chafers, *Dichelonyx spp.* were abundant in many places in eastern Canada in 1939. All hardwoods, particularly poplar, were attacked by *D. elongata* Fab. at Mashkode, Ont., and white birch over an area of 20 square miles near Holbein, Sask., were affected by *D. backii* Kby.

The rose beetle, *Macrodactylus subspinosus* Fab., was reported as spreading from apple and rose to cause an infestation on hardwoods at Cedar Valley, Ont.

The black sawyer, *Monochamus scutellatus* Say, caused damage to balsam (weakened possibly by budworm) at Red Cedar Lake and at Devil's Lake, to the south-west of the Temagami Reserve, Ont. Great abundance of this species was reported from two northern posts,—Red Lake, Ont., and Pukatawagan, Man.

The poplar borer, *Saperda calcarata* Say, presents a problem particularly in Saskatchewan. Although there was a marked decrease this year at Indian Head, 30 per cent of the poplar was infested at Carlyle, and infestations were heavy at Strasbourg and on the Keppel forest reserve. In Ontario, isolated poplars were found heavily attacked at Point Pelee and Leamington.

The linden leaf beetle, *Calligrapha scalaris* Lec., was reported as defoliating birch and maple at Dartmouth, N.S.

The cottonwood leaf beetle, *Chrysomela scripta* Fab., caused a moderate infestation on willow at St. Williams, Ont. The European poplar leaf beetle, *Chrysomela tremulae* Fab., was reported in great numbers near Edmonton, Alta.

The American poplar leaf beetle, *Phytodecta americana* Schffr, has given evidence in 1939 of moderate to severe outbreaks at Seebe and Bragg Creek, Alta., and Prince Albert National Park.

The cherry leaf beetle, *Galerucella cavicollis* Lec., defoliated a small area of red cherry at Garden Lake, Ont., as in 1938.

The alder flea beetle, *Altica ambiens alni* Harr., was not particularly conspicuous over Ontario and Quebec, the only centre of abundance reported being near Gogama, Ont. However activities were observed in central New Brunswick (Fredericton), and infestation was severe in several places in Charlotte county, notably Lawrence and Musquash. Small areas of complete defoliation occurred in western Nova Scotia, but the population was reduced from that of 1938. The western alder flea beetle, *Altica ambiens* var., heavily defoliated alder over a considerable area near Meadow Lake, Sask. A related species, probably *Altica plicipennis* Mann., heavily defoliated willow at Lethbridge, Alta.

The leaf-mining linden beetle, *Baliosus ruber* Weber, has been increasing yearly at La Trappe Que., and promises to cause considerable damage to basswood.

The mottled willow borer, *Cryptorhynchus lapathi* L., has been attacking planted poplars of various species in southern Ontario and Quebec, notably Berthier, Que., and Winona and Niagara Falls, Ont. Infestation on willow in the Vancouver district, B.C., continues, and the first record of attack on black cottonwood was obtained there.

The white pine weevil, *Pissodes strobi* Peck., has yielded many records of damage during the 1939 survey. Red ,Scots, and also white pine suffered severe damage at Sand Lake, Ont., a locality approaching the northern limits of these species. Thicket Portage, in northern Manitoba, gave a record of the weevil on spruce. A spruce hedge at Carp, Ont., was heavily attacked by this insect, accompanied by the spruce cone worm. Red pine near Singer, Que., white pine at Drummond Center, Ont., pine and spruce at Cheneville and L'Annonciation, Que., and mixed pine at Whitefish Lake, Algonquin Park, represent plantations suffering considerable damage.

The large spruce weevil, *Hypomolyx piceus* deG., has again been found to be distributed widely across Canada, far northern records extending from the Quebec shore of Hudson Bay to southern Yukon. By eating the cambium of roots near the ground-line, it has killed many planted Scots pine at Proulx, Que. This weevil is also abundant farther up the St. Maurice and in Co. Montmorency, Que.

The eastern larch bark beetle, *Dendroctonus simplex* Lec., was the species probably responsible for a fairly heavy infestation on tamarack, reported as dying, at Lohne's Lake, South Milford, N.S.

The mountain pine bark beetle, *Dendroctonus monticolae* Hopk., accompanied by *Ips interpunctus* Eichh., has largely subsided in the southwestern part of Kootenay National Park, B.C. However, there is still an

active infestation on lodgepole pine, mainly of *D. monticolae*, over an area of six square miles in the centre of the park on the west side of the Kootenay River.

The Douglas fir bark beetle, *Dendroctonus pseudotsugae* Hopk., has caused infestations around Lumby and at Columbia Lake, B.C.

Hemiptera

The forest soldier bug, *Podisus serieventris* Uhl., a valuable predator of leaf-feeding insects, has been found to occur abundantly throughout eastern Canada. Other common pentatomids are the three-spotted stink bug, *Euschistus tristigmus* Say, the banasa stink bug, *Banasa dimidiata* Say; the mottled stink bug, *Meadorus lateralis* Say, and the red-crossed stink bug, *Elasmostethus cruciatus* Say.

The box-elder plant bug, *Leptocoris trivittatus* Say, has given records of concentrations in Ontario, namely at Kenora, Grimsby in the Niagara peninsula, and as far east as Orono. Many similar records come from southwestern Manitoba, one at Mozart, Sask., and another at Vernon, B.C.

Homoptera

The pine spittle bug, *Aphrophora parallela* Say, has been exceptionally abundant this year on jack pine, Scots pine and white pine. Attack was heaviest on white pine, where it was associated in some obscure way with Needle Blight; the highlands north-west of Ottawa were the areas affected, damage being found at Kingsmere, Rowanton, Dumoine Lake and Hope Depot, and 50 square miles around Moosehorn Lake, west of Grand Lake Victoria, were affected in this way. Attack on jack pine was noticeable throughout the country north of Lakes Huron and Superior, particular records coming from Cartier and the Sioux Lookout district; it was also noted from the Sandilands Reserve, Man. south to the international border. Planted Scots pine at Spencerville, Ont., were affected, and white pine seedlings at Tichborne in the Eastern Townships were attacked.

The spruce gall aphid, *Adelges abietis* Kalt., was particularly noted in Frontenac and Stanstead counties, Que., at Spencerville, Golden Lake and Warwick, Ont., in the Riding Mountains, Man., south of Meadow Lake and on the Fort a la Corne Forest, Sask., and in the Yellowknife district, N.W.T.

The pine bark aphid *Adelges pinicorticis* Fitch, heavily attacked all white pine in Richardson township, Rainy River, Ont.

The larch woolly aphis, *Adelges strobilobius* Kalt., caused a heavy infestation on European larch at Midhurst, and a very heavy infestation on Japanese larch in Clarke township, near Orono, Ont.

The balsam woolly aphis, *Adelges piceae* Ratz., is causing widespread gout on balsam in the lower St. John valley, N.B., being extreme in many spots (e.g. Burton and Gagetown). Gout is becoming also prevalent along the Bay of Fundy coast in Charlotte and St. John counties.

The jack pine aphis, *Eulachnus rileyi* Williams, is becoming very abundant and markedly weakening jack pine on the Sandilands Reserve, Man.

The sycamore maple aphis, *Drepanosiphum platanoides* Schrank, is probably the species responsible for the unusually heavy attack on boulevard maples in 1939 in the city of Vancouver.

The balsam twig aphis, *Mindarus abietinus* Koch, is more abundant in New Brunswick than in previous years, and quite heavy infestations are common. The elm woolly aphis, *Eriosoma lanigera* Hausm., heavily infested white elm near Hillsdale, Ont., and was probably a main factor in the damage caused to elm at Outlook, Sask.

The poplar vagabond gall, caused by *Mordwilkoja vagabunda* Walsh, was abundant on poplar at Brent, Ont., following defoliation the previous year by the forest tent caterpillar. It was noted as quite abundant at Indian Head, Sask. Alder at the Experimental Farm, Ottawa, was found heavily infested by the alder blight aphis, *Prociphilus tesselata* Fitch.

The beech scale, *Cryptococcus fagi* Baer., has caused heavy infestations at Gagetown, Hampstead, Fredericton, Kennebecasis River, and other places in the lower St. John valley, N.B.

The jack pine scale, *Toumeyella numismaticum* Pett. and McD., syn. *pini* King, which reached the peak of its infestation in 1938, is now declining on the Sandilands Reserve, Man. There would appear to be a rapid fluctuation in the relation of this insect to its control factors.

The oak lecanium, *Lecanium quercifex* Fitch, was found heavily infesting certain white oaks at Leamington, Ont.

The spruce bud scale, *Physokermes piceae* Schr., heavily attacked Norway spruce at Petrolia, and from Simcoe to Cayuga, in southwestern Ontario.

The pine leaf scale, *Chionaspis pinifoliae* Fitch, a common pest of nursery and planted stock, was particularly noted on Scots pine at Leamington and Gananoque, and on Mugho pine at Ottawa, Ont. A sample of the juniper scale, *Diaspis carueli* Targ., was taken on Chinese juniper at Kingsville, Ont.

ORTHOPTERA

The walking-stick insect, *Diapheromera femorata* Say., appeared in great numbers at Pontypool, northwest of Oshawa, Ont., and seriously defoliated white birch.

DIPTERA

The oak fig gall. *Biorhiza forticornis* Walsh, was conspicuous on young bur oak along the Winnipeg River, Man.

The poplar pitch-ray miner, *Agromyza schineri* Giraud, was very abundant along Sabaskong Bay and south of Nestor Falls, Rainy River, Ont.

The balsam gall midge, *Cecidomyia balsamicola* Lint. sufficiently infested balsam foliage to cause needle-fall at Dorest, northern Haliburton Co., Ont.

The red pine gall midge, *Cecidomyia* sp., caused "fall browning" over 100 acres of red pine plantation at Orr Lake,, Ont. This represents a great increase of a trouble first observed in 1932 at Midhurst (2).

Acarida

The spruce spider-mite, *Paratetranychus ununguis* Jacobi, conspicuously damaged white pine in the town of Sault Ste. Marie, Ont., and heavily infested an ornamental spruce at Vernon, B.C.

The maple bladder-gall mite, *Phyllocoptes quadripes* Shim, caused a heavy infestation on red maple at Dorset, Ont. An outbreak has been persisting on silver maple at New Liskeard, Ont., for many years, but the attack was by far the heaviest this year.

Disease

The spruce needle rust, *Chrysomyxa* sp. or spp., will be mentioned because it formed a notable part of survey samples in 1939. Records came from clear across the northern forest belt from Yukon to eastern Newfoundland. It was particularly conspicuous in northern Saskatchewan and Manitoba, and all across northern Ontario. Its unusual prevalence may be associated with high midsummer humidities. Although its aspect is striking, damage may be expected only if infection continues over several consecutive years.

Acknowledgments

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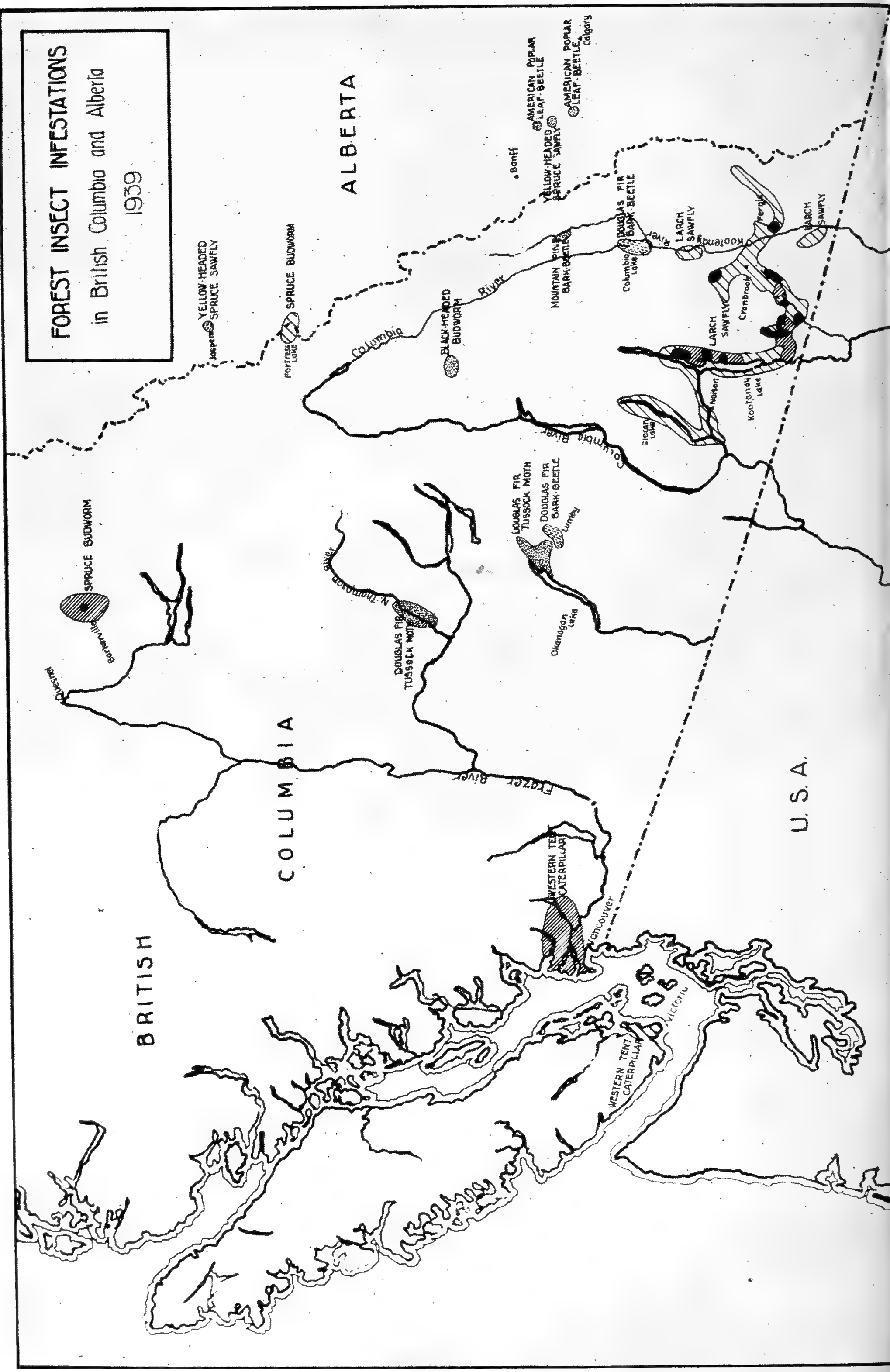

FOREST INSECT INFESTATIONS
in British Columbia and Alberta
1939
ALBERTA
BRITISH
COLUMBIA
U.S.A.
YELLOW-HEADED SPRUCE SAWFLY
Jasper
SPRUCE BUDWORM
Fortress Lake
Columbia
River
BLACK-HEADED BUDWORM
Banff
YELLOW-HEADED SPRUCE SAWFLY
AMERICAN POPLAR LEAF-BEETLE
AMERICAN POPLAR LEAF-BEETLE
Calgary
MOUNTAIN PINE BARK-BEETLE
DOUGLAS FIR BARK-BEETLE
Columbia Lake
LARCH SAWFLY
Kootenay
River
Fernie
LARCH SAWFLY
LARCH SAWFLY
Cranbrook
Nelson
Kootenay Lake
Slocan Lake
Columbia River
DOUGLAS FIR TUSSOCK MOTH
DOUGLAS FIR BARK-BEETLE
Lumby
Okanagan Lake
N. Thompson River
DOUGLAS FIR TUSSOCK MOTH
SPRUCE BUDWORM
Barkerville
Quesnel
Frazer River
WESTERN TENT CATERPILLAR
Vancouver
Victoria
WESTERN TENT CATERPILLAR

A SUMMARY STATEMENT IN REGARD TO SOME OF THE MORE IMPORTANT INSECT PESTS IN CANADA IN 1939

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Division of Entomology, Science Service Department of Agriculture, Ottawa

Field Crop and Garden Insects

Grasshoppers were again widespread in the Prairie Provinces in 1939, but, owing largely to improved moisture conditions and effective control activities, crop losses in the more important grain-growing areas were much less serious than had been anticipated. As in previous years, the lesser migratory grasshopper, *Melanoplus mexicanus* Saus., and the clear-winged grasshopper, *Camnula pellucida* Scud. were the most important species in the Prairie Provinces. Throughout Eastern Canada damage by grasshoppers was reported only locally, and in British Columbia the outbreak of the past few years had largely subsided. Further details follow:

In Manitoba, the comparatively light outbreak of the previous year increased in range and intensity during 1939, despite the activities of bee-flies and blister beetles which destroyed large numbers of eggs. This was due to migrations of the lesser migratory grasshopper across the border, in 1938 and 1939, and to increased abundance of the clear-winged grasshopper. Damage to crops was reduced to a minimum by an efficient control campaign, but was most severe in the south, along the Pembina valley, where more than 1000 eggs per square foot had been laid in pastures and clearings in the bush.

In Saskatchewan, practically the entire farming area of about 100,000 square miles was infested. The lesser migratory grasshopper was dominant in the prairies, and the clear-winged grasshopper was most abundant towards the northern wooded region, where the heaviest infestations occurred. Copious June rains and a well organized control campaign, however, greatly reduced injury to crops in the spring and, even in the worst infestations, only small marginal losses occurred. In July, large flights of grasshoppers migrated into southwestern Saskatchewan from Montana and caused considerable crop losses from Masefield to the Alberta border, over an area which had previously been uninfested. Migrating grasshoppers also invaded other southern areas, but caused little injury except to crops in the drought-stricken region in the southeast.

In Alberta, grasshoppers were present over the entire southern third of the province, but in many areas their numbers were apparently reduced by wet weather in June. The most serious damage was caused by first-instar nymphs which hatched in stubbled-in crops during the extremely dry weather in May. For the first time since the oubtreak started records were secured of a migration of the lesser migratory grasshopper into southeastern Alberta from Montana, commencing about mid-July. Some of these flights reached districts about 150 miles north of the border, but enormous numbers of the grasshoppers remained in the southeast corner of the province and did great damage to crops.

*Prepared at the direction of the Dominion Entomologist from regional reports submitted by officers of the Division of Entomology, and members of the Entomological Society of Ontario. The original reports are included in the first issue of Volume 18, of the Canadian Insect Pest Review.

In British Columbia, grasshoppers suffered a marked decline in abundance, and were present in injurious numbers only in a few scattered areas.

In Eastern Canada, grasshoppers were responsible for some reports of damage. A number of young apple trees were defoliated locally in Kings county, Nova Scotia, and some apple, pear and peach trees were attacked in the Niagara peninsula, Ontario. Grasshoppers were moderately abundant in eastern New Brunswick where they damaged the foliage of turnips and garden vegetables. They were also quite injurious to crops in the vicinity of Quebec, Province of Quebec, and in several counties to the south. In eastern Ontario they were numerous enough in some localities to necessitate control measures.

The mormon cricket, *Anabrus simplex* Hald., which caused some apprehension in Saskatchewan in 1938, was much less abundant in 1939.

Heavy June rains greatly reduced the infestation of pale western cutworm, *Agrotis orthogonia* Morr., in Saskatchewan and Alberta, and prevented serious crop losses. On the other hand, the red-backed cutworm, *Euxoa ochrogaster* Gn., and allied species increased in abundance in Saskatchewan, and were troublesome in gardens and caused some damage to grain crops in southeastern and northwestern sections. There was a widespread outbreak of this species (the worst on record) in the Peace River area of Alberta, and the pest was also abundant west of Edmonton. Severe crop losses occurred over a wide area.

The army cutworm, *Chorizagrotis auxiliaris* Grote, was abundant in southeastern Alberta and southwestern Saskatchewan, and, in the former province, caused damage to early-seeded wheat in several localities.

Cutworms were a severe pest in British Columbia in 1939. In Manitoba they were reported about normal. No serious outbreaks occurred in Eastern Canada; in Ontario they were noted as very scarce.

The armyworm, *Cirphis unipuncta* Haw., was notably scarce in 1939, and no reports of damage were received from any of the provinces which suffered outbreaks in 1937 and 1938, extending from Saskatchewan to the Atlantic seaboard.

Although wireworms, chiefly *Ludius aeripennis destructor* Brown, again caused severe and widespread damage in Saskatchewan, the losses were considerably less than in 1938. In southwestern and west-central Saskatchewan, the losses were much less than had been expected owing to mid-summer rains, which enabled the injured crops to recover. However, in the dry southeastern areas damage was greater than in previous years. Severe crop losses also occurred in the central area of the province, especially on light and medium soils, in the east-central parklands, and in the northwest as far north as Meadow Lake. In Manitoba, wireworms were reported increasing in numbers in medium soils in the southwest, where in some districts damage averaged 25 per cent of the crops. In northern Alberta, there were no complaints regarding these insects, except in the Peace River district.

The wheat stem sawfly, *Cephus cinctus* Nort., continues to be an important pest in the Prairie Provinces. Increases in abundance were noted in Manitoba, particularly western Manitoba, and in Saskatchewan. In the latter province, the infestation extended over the greater part of the prairie

region and a considerable margin of the park belt. In south-western and south-central Saskatchewan, margins of fields over a wide area were 20-30 per cent infested. In Alberta, the species was abundant over a large proportion of the province south and east of Edmonton. Losses were reduced by harvesting methods except in the case of later crops, the cut stems of which were levelled to the ground by early autumn rains. In Ontario, the eastern wheat stem sawfly, *C. pygmaeus* L., was found to be present over a large part of the province, but was abundant chiefly in several counties along the north shore of Lake Ontario. Apparently, losses due to this species were not serious .

The hessian fly, *Phytophaga destructor* Say, was unusually abundant in east-central Alberta, and northern and west-central sections of Saskatchewan, and in some localities caused considerable damage to wheat.

In Manitoba, the wheat stem maggot, *Meromyza americana* Fitch, destroyed from 2 to 5 per cent of wheat in the Red River valley and the Interlake district, and was possibly the most destructive insect to the crop in these districts.

Say's stink bug, *Chlorochroa sayi* Stahl., continued to increase in south-western and south-central Saskatchewan, but is not yet of significant economic importance in that province, the main infestation occurring on idle, weed-grown land. It has spread to new areas in Alberta, and is now fairly generally distributed south of a line extending from Calgary to Empress. The most northerly record is Lousana, about thirty miles from Edmonton. In some areas the infestation on wheat was severe, and in several localities potatoes were damaged. Specimens were collected in south-western Manitoba, at Brandon and Lyleton, and constitute new records of the eastern distribution of this species.

The false chinch bug, *Nysius ericae* Schill., was very abundant in Saskatchewan and Alberta in 1939. In the former province no damage to crops was reported, but an outbreak in 1940 may be impending. In Alberta, various crop plants were attacked, including sugar beets, alfalfa, potatoes and mangels.

A heavy infestation of white grubs was present in a group of counties in Ontario north of Lake Ontario, notably in the counties of Hastings and Peterborough. At least 50,000 acres were involved. The greatest injury occurred in rough pastures, but other crops including grain also suffered serious damage.

The infestation of the potato and tomato psyllid, *Paratrioza cockerelli* Sulc., was considerably reduced in Saskatchewan and Alberta compared with 1938. The area involved was generally the same, but the population was smaller and more scattered. Serious loss occurred only locally, notably at Medicine Hat, Calgary and Lethbridge, Alberta. This species was found in eastern British Columbia in 1938, but a survey failed to reveal its presence in 1939.

The tobacco worm, *Phlegethontius quinquemaculata* Haw., was again abundant on tobacco and tomato in Ontario during 1939. The species also caused some damage to tobacco in southern Quebec.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, was again a serious pest throughout its range.

Damage to potatoes by the potato flea beetle, *Epitrix cucumeris* Harr., was reported in New Brunswick and southern Quebec. The species was less abundant than average in Ontario. The crucifer flea beetle, *Phyllotreta lewisi* Cr., was one of the most destructive insects on cruciferous crops in market gardens in the Winnipeg and Brandon districts, Manitoba. The hop flea beetle, *Psylliodes punctulata* Melsh. was abundant throughout Alberta and was reported as far north as Fort McMurray.

The sweet clover weevil, *Sitona cylindricollis* Fab., which had not previously been recorded west of the Georgian Bay, in Ontario, was found to be widely distributed in Manitoba, in 1939. and caused damage to sweet clover in many localities. It is believed that the species may have been present in the province for some years.

In 1939, for the first time, the bill bug, *Calendra aequalis* Gyll., was found in Manitoba. This was near Pilot Mound, where wheat and, to a lesser extent, barley were attacked.

As in past years, blister beetles of several species were common pests in the Prairie Provinces. Caragana windbreaks and various field and garden crops were attacked.

The onion thrips, *Thrips tabaci* Lind., was present in injurious numbers on onions in the Harrow-Leamington district of southwestern Ontario, and in the Winnipeg district, Manitoba.

The onion maggot, *Hylemyia antiqua* Meig., and the cabbage maggot, *H. brassicae* Bouche, were reported more abundant than usual in Alberta, and causing economic damage in parts of Quebec. Crop injury by both species was below average in Ontario.

As usual, the imported cabbage worm, *Pieris rapae* L., was a very common pest in various parts of Canada, especially during the latter part of the season. In Nova Scotia it was probably less injurious to turnips than during the previous two years. In Saskatchewan it was reported abundant and destructive in northern parts of the province.

The red turnip beetle, *Entomoscelis adonidis* Pallas, was abundant on cruciferous crop plants and weeds in west-central Saskatchewan and central Alberta. Local damage occurred in gardens.

There was a reduction in the percentage of infestation of the European corn borer, *Pyrausta nubilalis* Hbn., in cornstalks in the southwestern counties of Ontario, as compared with 1938. In the more northern counties, from Goderich on Lake Huron eastward to the Quebec border, the infestation definitely increased, doubtless as a result of more favourable weather conditions. Both sweet corn and field corn were affected. This increase extended into southern Quebec.

In general, the beet webworm, *Loxostege sticticalis* L., was less abundant and injurious in the Prairie Provinces than in 1938. The larvae caused local damage in gardens in south-central Manitoba and central Saskatchewan, and also attacked alfalfa fields in the latter province, destroying as much as 50 per cent of the foliage of the second crop.

For the first time since 1931, an infestation of the sugar beet nematode, *Heterodera schachtii* Schmidt, was found in Ontario. This was in a ten-acre field of beets near Sarnia. No other infestations were found, although a survey was made. Steps have been taken to prevent the spread of the pest and to eliminate it from the area affected.

The tarnished plant bug, *Lygus pratensis* L., was again prevalent in the Maritime Provinces, Quebec, and Ontario. Potato crops as well as vegetable and flower gardens were attacked. Celery which was severely infested locally in southern Quebec and at Algonquin, Ontario, in 1938, suffered only slight damage in 1939.

In the Victoria, New Westminster and Agassiz districts of British Columbia, the European earwig, *Forficula auricularia* L., was reported more abundant in 1939 than in 1938, and was a general pest in gardens and dwellings. The young earwigs attacked seedling vegetables, especially carrots, and also damaged flowering plants such as dahlias and gladioli. In Ontario, where it was recorded for the first time in 1938 in the village of Ayton, it has spread to neighbouring communities.

Potato aphids, including *Macrosiphum solanifolii* Ashm., and other species, occurred in relatively small numbers in potato fields inspected in Quebec. There was a heavy infestation of the cabbage aphid, *Brevicoryne brassicae* L,. in turnips in southern Ontario from Peel county to Middlesex county, some fields being almost ruined. Much damage by this species to turnips was also reported in Prince Edward Island. The infestation in Quebec was comparatively light. The corn-leaf aphid, *Aphis maidis* Fitch, was locally abundant in southern Quebec and southwestern Ontario, and in the latter region several fields of corn were decidedly weakened. The pea aphid, *Illinoia pisi* Kalt., was unimportant in Quebec in 1939. A number of species of aphids were very abundant in Saskatchewan in June, but were reduced by predators as the season advanced. These insects were also abundant on alfalfa in southern Alberta.

Fruit Insects

On the whole, the codling moth, *Carpocapsa pomonella* L., was somewhat less injurious in apple-growing sections of Nova Scotia than in 1938. Heavy infestations occurred in a few orchards, but where spray recommendations were followed there was a considerable reduction in injury, especially that caused by "stings". The species was quite common in orchards of southern Quebec, particularly in the St. Hilaire region. In some orchards in the Niagara Peninsula and in Essex county, Ontario, the insect was very destructive, doubtless because conditions favoured a large second brood. Elsewhere in the province, it was apparently no more injurious than it had been in recent years. It was noted that the species is becoming increasingly important in pear orchards, particularly in the Niagara district where, according to reports from canners, Bartlett pears were considerably more wormy than in 1938. In British Columbia, injury by the codling moth was general throughout the Okanagan and Similkameen valleys, but losses to fruit were 20-30 per cent less than in 1938.

The situation in regard to the apple maggot, *Rhagoletis pomonella* Walsh, continued satisfactory in commercial orchards located in control zones established by the provincial apple maggot control boards in apple-growing sections of Eastern Canada.

Apple orchards were infested in varying degree by several species of aphids during 1939. As in 1938, the rosy apple aphid, *Anuraphis roseus* Baker, was numerous in the Annapolis valley, Nova Scotia, but was prevented by control measures from becoming of major importance. Scattered outbreaks developed in orchards in Ontario, but natural control agencies prevented these from becoming more widespread. Favoured by cool, moist

weather, this species was also prevalent in closely planted orchards in the Okanagan and Kootenay districts of British Columbia. The apple aphid, *Aphis pomi* DeGeer, was troublesome in a number of highly vegetative orchards and nurseries in the Annapolis valley during the summer and necessitated the application of special treatments. It was also abundant on young apple trees in southern Quebec, causing injury to tender terminal growth. Local outbreaks were reported in different parts of Ontario. The apple grain aphid, *Rhopalosiphum prunifoliae* Fitch, occurred in unusual abundance on apple in early spring, in the Annapolis valley, Nova Scotia, and southern Ontario, but caused no appreciable commercial loss. Local heavy infestations of the woolly apple aphid, *Eriosoma lanigera* Hausm., developed in certain orchards in the Okanagan valley, British Columbia. Apparently unusually cool weather in May and June reduced the effect of the parasite *Aphelinus mali* Hald.

The gray-banded leaf roller, *Eulia mariana* Fern., showed an increase in many orchards in the Annapolis valley, Nova Scotia, where careful spraying was not carried out. The oblique-banded leaf roller, *Cacoecia rosaceana* Harr., the three-lined leaf roller, *Pandemis limitata* Rob., the dusky leaf roller, *Amorbia humerosana* Clem., and the white-triangle leaf roller, *Cacoecia persicana* Fitch, were not of much importance in this region. In Ontario, the fruit tree leaf roller, *Cacoecia argyrospila* Wlk., was responsible for a considerable amount of injury in a number of orchards east of Toronto. Light infestations were observed in Norfolk county. Leaf rollers were troublesome in several counties in southern Quebec.

The eye-spotted budmoth, *Spilonota ocellana* D. & S., was again troublesome in many Nova Scotia orchards. There was a slight to moderate increase in eastern Kings county. In other sections there was no marked change. In southern Ontario, the budmoth was more generally abundant than previously experienced, notably in Norfolk, Elgin, Lambton and Wellington counties, and along the north shore of Lake Ontario.

Tussock moths were somewhat more destructive in Nova Scotia orchords than in 1938. In the western part of Annapolis county, the white-marked tussock, *Hemerocampa leucostigma* S. & A. and the rusty tussock, *Notolophus antiqua* L., of which the former was probably the more numerous, caused damage. The spring canker worm, *Paleacrita vernata* Peck, was also destructive to fruit and shade trees in the South Shore area. The damage was probably the heaviest during the current outbreak.

Heavy infestations of the cigar case bearer, *Haploptilia fletcherella* Fern., were observed in orchards locally in Norfolk county, Ontario, but elsewhere they appeared to be of minor importance, except in some neglected orchards.

Injury by the buffalo tree hopper, *Ceresa bubalus* Fab., to young apple trees was particularly severe in orchards in the Georgian Bay district, Ontario, where late potatoes had been grown in between the rows in 1938. The potato is indicated as a favourite food plant of this species.

The white apple leafhopper, *Typhlocyba pomaria* McAtee, was less abundant in orchard districts of Nova Scotia and Ontario than in 1938. In British Columbia, however, where its importance as a pest in the interior fruit districts is increasing, it was very numerous in many orchards, particularly at Kelowna and Vernon, and in some instances necessitated washing of the fruit to remove the brown deposit resulting from its presence.

The mullein leaf bug, *Campylomma verbasci* Meyer, which in 1938 was prevalent and injurious to apples throughout the Annapolis valley, Nova Scotia, showed a heavy reduction in 1939, and very little damage was done, although a few of the insects appeared in some orchards and nurseries.

In general, the apple mealy bug, *Phenacoccus aceris* Sig., was not of any great importance in Nova Scotia during 1939, except in a few orchards in Hants county. This species is a serious pest of fruit in some sections of the Kootenay valley, in British Columbia, where it is slowly spreading.

As in 1938, the European red mite, *Paratetranychus pilosus* C. & F. was not numerous early in the 1939 season in Nova Scotia apple-growing districts, but developed during the summer and, by the middle of August, could be found in outbreak form in many orchards. Shortly afterwards it disappeared rapidly, no severe damage was done, and the number of winter eggs deposited was not above normal. In Ontario it was of no great importance, but was more conspicuous on apple than on European plum. In the Okanagan valley of British Columbia, the species was also less troublesome than in 1938. However, in one locality peaches were more heavily attacked than usual. In the latter province, the Pacific mite, *Tetranychus pacificus* McG., which is a serious pest in central Washington state, was reported for the first time, in July, in a nursery at Grand Forks. Later it was found to be established over a considerable area in the Oliver district.

The plum nursery mite, *Phyllocoptes fockeui* Nal. and Trt., caused relatively little damage in the Niagara district, Ontario, during the early part of the season when it is usually most injurious, but vigorous tree growth following heavy rains, and the absence of predators allowed a large population to develop during August which caused much injury.

The oyster shell scale, *Lepidosaphes ulmi* L., was again troublesome in central and eastern Kings county, Nova Scotia, but control measures in infested orchards reduced the amount of damage as compared with that in 1938. The species was scarce in British Columbia, apparently as a result of very hot weather in June and July of the previous season, and the activities of the predatory mite *Hemisarcoptes coccisugus* Sig. The San Jose scale, *Aspidiotus perniciosus* Comst., continued at a low ebb in southern Ontario, with a slight increase in Norfolk county. In the Okanagan valley, British Columbia, the scale is gradually spreading and infestations occur in several localities, including Kelowna, Keremeos, Osoyoos, Spences Bridge and Kaslo.

In orchards in the Niagara peninsula, Ontario, where the green stink bug, *Acrosternum hilaris* Say, produced severe injury on pears and to a lesser extent on peaches in 1938, only an occasional bug was found in 1939, and no commercial injury was observed. In southwestern Ontario, however, the insect wes destructive in some peach and pear orchards, especially in the Ruthven - Leamington district.

The infestation of the oriental fruit moth, *Grapholitha molesta* Busck., in the Niagara Peninsula, Ontario, was somewhat higher than in 1938, and in a few orchards was quite high, especially on Elbertas; in most orchards, however, it was below one per cent. In southwestern Ontario, the outbreak, which reached its peak in 1937, showed a further decline and, in 1939, was generally less than one per cent.

The peach tree borer, *Sanninoidea exitiosa* Say, caused quite heavy losses in Essex county, Ontario, several young orchards being practically ruined. In the Niagara district, reports of borer injury were fewer than in 1938, and there was less infestation of nursery stock.

The tarnished plant bug, *Lygus pratensis* L., was abundant in southern Ontario and responsible for much injury to fruit tree nursery stock, particularly peach.

Cherry fruit flies, *Rhagoletis* spp., which have been of minor importance in the Niagara district, Ontario, in recent years, heavily infested late sweet cherries in a lake shore orchard near Beamsville. A brief survey on Vancouver Island, British Columbia, in August, 1939, showed that the species *R. cingulata* Loew. is present in nearly all parts of the fruit districts north of Victoria, from the city limits to Gordon Head and Keating.

The black cherry aphid, *Myzus cerasi* Fab., was unusually prevalent on sour cherries in the Niagara district, Ontario. In sweet cherry orchards the infestation was moderate to heavy.

Grape leafhoppers, *Erythroneura comes* Say and *E. tricincta* Fitch, were less abundant and injurious in the Niagara district, Ontario, than in the previous two seasons.

The strawberry weevil, *Anthonomus signatus* Say, was prevalent and injurious in the Maritime Provinces and southern Quebec. In the Niagara district and Norfolk county, Ontario, spittle bugs, *Philaenus leucopthalmus* L., were very abundant in strawberry plantations and caused some damage; in one case this amounted to 30 per cent of the fruit.

Forest and Shade Tree Insects

There was not much change in the known distribution of the European spruce sawfly, *Gilpinia polytoma* Hartig., during 1939. The species occurs throughout a large part of the Maritime Provinces, and in Quebec and eastern and southern Ontario. In the Gaspe, which is heavily infested, there was no material change in the infestation, but a further mortality of trees in this area brought the total to about 74 per cent of white spruce and 43 per cent of black spruce. Elsewhere in Quebec, mortality occurred only at scattered points and was nowhere severe. In New Brunswick, unfavorable weather conditions resulted in a somewhat higher degree of diapause and greater larval mortality, contributed to in some localities by a disease which previously had been of minor importance in the field. Large numbers of the sawfly were also destroyed by imported parasites.

Scattered outbreaks of the yellow-headed spruce sawfly, *Pikonema alaskensis* Roh.. continued on open-grown spruce from New Brunswick to the Rockies; the most severe infestations were apparently centred in the Province of Quebec.

Several thousands of square miles of forested country in Ontario north of Lake Huron and east of Lake Superior were heavily infested by the spruce budworm, *Cacoecia fumiferana* Clem., in 1939, and great numbers of balsam and white spruce are dead or dying as a result of the attacks of this species and of secondary insects. Heavy mortality of mature balsam has also occurred in the Barkerville district, British Columbia, where an infestation of long standing has spread considerably. Light to moderate infestations were reported in various other localities in the above provinces and in Quebec, Manitoba and Alberta.

The jack pine budworm (considered a biological race of *C. fumiferana*) continued active over a wide territory west of Lake Superior, from Port Arthur in northwestern Ontario into southwestern Manitoba as far as Sandilands, and northward to the Winnipeg River. Localized heavy infestations also occur at Fort a la Corne and in the vicinity of Prince Albert, Saskatchewan. Scattered infestations were found on hard pines in southeastern Ontario.

The black-headed budworm, *Peronea variana* Fern., occurred only in inconspicuous numbers in Eastern Canada in 1939. In British Columbia it was found in many localities and a fairly extensive outbreak was reported in Glacier Park.

The balsam woolly aphid. *Adelges piceae* Ratz., continued on the increase at a number of points in southern New Brunswick and single trees and small groups of trees were killed locally throughout the infested region.

Infestations of the spruce gall aphid, *Adelges abietis* Kalt., were reported in a number of localities in Quebec, Ontario, Manitoba and Saskatchewan. In Ontario, this species and *A. cooleyi* Gill., were reported injurious to spruce throughout the province.

The outbreak of hemlock looper, *Ellopia fiscellaria* Gn., in the Parry Sound district, Ontario, is apparently dying out. The infestations of the western hemlock looper, *E. fiscellaria lugubrosa* Hlst., in British Columbia at Wilson Lake and in the Waterton Lakes Park have completely subsided.

An area of about 500 square miles northeast of Okanagan Lake, British Columbia, was infested by the Douglas fir tussock moth, *Hemerocampa pseudotsugata* McD. Many isolated infestations, some covering several square miles in area, also appeared in the northern part of the Okanagan valley, and a medium infestation was reported in the north Thompson valley. A wilt disease caused high mortality among the larvae.

The Douglas fir bark beetle, *Dendroctonus pseudotsugae* Hopk., caused the death of many trees at Columbia Lake and in the Lumby district, British Columbia.

The red-headed pine sawfly, *Neodiprion lecontei* Fitch, continued on the decline in the Mattawa—North Bay — Laniel area in Ontario and western Quebec, but south and west of that region several infestations were reported. Plantations of red pine near Burke's Falls and Parry Sound suffered some damage from small outbreaks. At the Kirkwood Plantation, where several million young pines had been planted, a severe outbreak developed and hundreds of trees were killed and thousands severely damaged. The species was also abundant in south-central Ontario. In the Biscotasing-Chapleau area of Ontario, jack pine was heavily attacked by a species of *Neodiprion* closely resembling that found on red pine near Laniel, and trees in the open and on rocky exposed points lost as much as 75 per cent of their old foliage.

The jack pine sawfly, *Neodiprion banksiana* Harr., has greatly increased in numbers on jack pine in northwestern Ontario and Manitoba. It was most active in the Ontario forests from Kenora to Dryden and south to Fort Frances. In Manitoba, it was particularly abundant on the Sandilands Forest Reserve in the southern part of the province. It was also active in the Fort a la Corne region of northern Saskatchewan.

Notable infestations of the balsam fir sawfly, *Neodiprion abietis* Harr., occurred in Ontario on balsam along the east shore of Lake Superior and the North Channel of Lake Huron, and along the Ottawa River from Ottawa to Hawkesbury. There was also an outbreak on Isle Madame, Nova Scotia, which caused noticeable defoliation of spruce and balsam at a number of points.

The lodgepole pine sawfly, *Neodiprion* sp., was reported from various points in British Columbia and was abundant at Trinity Valley, in the interior.

Parasites and predators have reduced the outbreak of jack pine scale, *Toumeyella numismaticum* Pett. & McD., to neglible proportions in the Sandilands Reserve, in southern Manitoba. During 1938, 25,000 acres were infested by this insect, which caused severe injury to the young growth of jack pine.

Infestations of the larch sawfly, *Pristophora erichsoni* Htg., of varying degree of intensity were reported across Canada from Nova Scotia to southeastern British Columbia. The infestations were heavy in Charlotte county, southern New Brunswick; in Ontario east of Lake Superior and northeast of the Georgian Bay, and in British Columbia in the Fernie - Cranbrook - Nelson area. Elsewhere they were moderate to light.

The larch case bearer, *Haploptilia laricella* Hbn., appeared in increased numbers throughout Nova Scotia, causing widespread browning of the foliage in the early summer. In New Brunswick it was much less numerous and caused only occasional browning of trees. Except for local heavy infestations, the situation was also easier in Quebec and southern Ontario.

There was a decided decrease of the forest tent caterpillar, *Malacosoma disstria* Hbn., in Eastern Canada, and the extensive outbreak in northwestern Ontario, which had been in progress since 1931, completely subsided. Although still present in outbreak numbers in the Kipawa Lake region, the infestation was apparently decreasing in intensity. In Ontario the main infestation was found east of Algonquin Park and south of the Ottawa River in the valleys of the Madawaska and Bonnechere rivers. Severe infestations persist north of the prairies in the Prairie Provinces.

The satin moth, *Stilpnotia salicis* L., was reported less prevalent in 1939 in the Annapolis valley, Nova Scotia, although it caused defoliation of small groups of poplar in some localities. Defoliation of poplars also occurred at scattered points in Prince Edward Island and southern New Brunswick. A new heavy infestation was discovered at Bathurst, New Brunswick, about 100 miles north of the nearest known infested area. The species was also found for the first time in Quebec, near Quebec City, over an area extending from Beauport to Cap Rouge.

The poplar borer, *Saperda calcarata* Say, was present in the Prairie Provinces wherever native stands of aspen occur. Much injury occurred in stands of poplar in northern Saskatchewan.

The fall cankerworm, *Alsophila pometaria* Harris, is the most important pest of boxelder in the prairie region of Manitoba and Saskatchewan. Severe defoliation of the host trees occurred in many localities. In Eastern Canada, the species was again numerous in the Saint John valley, New Brunswick, although somewhat less so than in 1938.

The cecropia moth, *Platysamia cecropia* L., ranked second in importance to the fall cankerworm as a pest of deciduous shelterbelts on the prairies in southern Saskatchewan. The larvae caused some defoliation of boxelder over a wide area.

The beech scale, *Cryptococcus fagi* Bsp., increased again in southern New Brunswick and parts of Nova Scotia. Most of the mature stands have been practically destroyed in Nova Scotia, and the mortality in New Brunswick is spreading northward. Already many fine stands in the southern quarter of New Brunswick are dead or dying. Heavy infestations have developed as far north as Douglas Township, York county.

The bronze birch borer, *Agrilus anxius* Gory, continues as a destructive pest of birch from the Maritimes to Saskatchewan, being particularly injurious in New Brunswick and northern Manitoba and Saskatchewan. The damage in New Brunswick is most severe from the Miramichi River to the south coast. Studies on logging operations indicated that about 30 per cent of the trees selected for high grade lumber or veneer logs contained larvae in the stem and were in a dying condition. In the West, the heaviest losses resulting from the attacks of this insect have occurred in Prince Albert National Park, Saskatchewan.

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Ontario Department of Agriculture

Seventy-First Annual Report

of the

Entomological Society

of Ontario

1940

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FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31ST, 1940

Receipts

Cash on hand in Bank	$ 540.62
Dues	322.25
Subscriptions	453.97
Advertising	219.95
Back Numbers	35.95
Bank Interest & Exchange	16.62
Government Grant	350.00
Miscellaneous	21.38
	$1,960.74

Expenditures

Printing Canadian Entomologist	$1,110.00
Postage	45.90
Bank Exchange	5.02
Honoraria & Stenographic Assistance	280.00
Annual Meeting	35.62
Miscellaneous	50.89
Balance on hand in Bank	433.31
	$1,960.74

Audited and found correct
L. CAESAR,
H. W. GOBLE, *Auditors*.

Respectfully submitted,
REG. H. OZBURN,
Secretary-Treasurer.

Entomological Society of Ontario

REPORT OF THE COUNCIL 1939-1940

On the invitation of the president, Dr. Maheux of the Department of Agriculture of the Province of Quebec, the seventy-sixth annual meeting was held at the Chateau Frontenac, Quebec City, on November 2nd, 3rd and 4th, 1939. Ample accommodation for the regular meetings devoted to the presentation of general papers and their discussion was provided by the management of the Chateau.

On Thursday afternoon the members of the Society were entertained at the Duchesnay Forest Rangers School where papers dealing with forest entomology were read and discussed. Following the presentation of these papers the Government of Quebec, under the auspices of the Department of Lands and Forests, entertained the Society at an enjoyable dinner at the School. Mr. Roy, Director of the School, extended a hearty welcome to the members present, after which the Deputy Minister of Agriculture for the Province of Quebec spoke briefly. During the evening Dr. Maheux gave the presidential address on "The development of entomology in Quebec".

Friday afternoon the members were taken on a tour of the outstanding historical spots in and around Quebec City. The tour terminated at the Provincial Museum where tea was served.

Friday evening the members assembled in the Chateau Frontenac and enjoyed a program of French-Canadian songs, group singing and motion pictures, arranged by the local committee.

During the course of the meetings, at which forty-five papers were presented, one hundred and eighty-six members and visitors were registered.

The Council is happy to report that the Index to the Annual Reports of the Society from 1900 to 1937, published through the courtesy of the Department of Agriculture, Province of Ontario, was mailed to the members and to the subscribers to the journal shortly after the last annual meeting. The Seventieth Annual Report for 1939 was mailed early this October.

It is the sad duty of the Council to record the death of Dr. A. J. Hunter of Teulon, Manitoba, a member of the Society for over thirty-five years.

The Council also records with sorrow the deaths of Dr. E. P. Van Duzee of the California Academy of Sciences, and H. C. Fall of Tyngsboro, Massachusetts. These two entomologists were associated with the Society for over twenty-five years.

The journal of the Society, the Canadian Entomologist, completed its seventy-first volume in December, 1939. This volume of 268 pages illustrated by 27 plates and 32 figures contained 71 articles, 13 book notices and 6 news items. These articles were contributed by sixty authors including writers in eight provinces of the Dominion and sixteen states of the Union.

RECORD OF PAPERS PRESENTED AT THE 77TH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, HELD IN GUELPH, ONT., NOVEMBER 7-8TH, 1940.

Report of Activities ot "Le Comite au Musee Provancher"—Noel M. Comeau, Provincial Museum, Quebec, P. Q.

"Improved Method for the Preservation of Coniferous Foliage for Exhibition Purposes"—H. A. Raizenne, Division of Entomology, Ottawa.

"A Rare Migration of *Cacoecia cerasivorana*"—Georges Maheux, Plant Protection Service, Quebec.

"Spraying for the Control of European Corn Borer in Sweet Corn"—G. M. Stirrett, Dominion Entomological Laboratory, Chatham, & R. W. Thompson, O. A. C.

"Biology and Control of the European Corn Borer in Quebec"—Georges Gauthier, Plant Protection Service, Quebec.

"An Important Development in the Corn Borer Parasite Situation"—Geo. Wishart, Dominion Parasite Laboratory, Belleville.

"Effects of Trap Crops on Corn Borer Infestation"—Pellerin Lagloire, Plant Protection Service, Quebec.

"Hybrid Corn in the Corn Borer Control Program with notes on the 1940 situation in Ontario"—, R. W. Thompson, Ontario Agricultural College.

"Some Greenhouse Insect Problems in Ontario"—G. G. Dustan, Vineland Station.

"Introductory Notes on Larvae of the Geometridae"—W. C. McGuffin, Division of Entomology, Ottawa.

"The Provancher Entomological Collections"—Noel M. Comeau, Provincial Museum, Quebec, P. Q.

"A Simple Method for Use in Staining Aphids and Rearing *Myzus persicae* Indoors in Winter"—R. P. Gorham, Dominion Entomological Laboratory, Fredericton, N. B.

"Distribution Records and Key to the Mosquitoes in Canada"—C. R. Twinn, Division of Entomology, Ottawa.

"Notes on a Species of *Tapinoma* New to Canada"—E. R. Bellemare, Montreal, Que.

"Some new Lectotypes of Hymenoptera described by Provancher"—Noel M. Comeau, Provincial Museum, Quebec, P. Q.

"Successful Hibernation of the Earwig Parasite *Digonichaeta setipennia* Fall. in Ontario"—C. W. Smith, Dominion Parasite Laboratory, Belleville.

"Biological Control of the Codling Moth in Ontario"—H. R. Boyce, Dominion Parasite Laboratory, Belleville.

"Two Codling Moth Parasites Introduced from Europe"—Miss D. Naphtali, Dominion Parasite Laboratory, Belleville.

"Life History Studies on *Apanteles carpatus* (Say), (Hymenoptera: Braconidae) A Parasite of the Clothes Moth"—A. Murray Fallis, Ontario Research Foundation, Toronto.

"Differences in the Preferendum of a Chalcid Parasite, *Microplectron fuscipennis* Zett. Produced by Selection"—Alfred Wilkes, Dominion Parasite Laboratory, Belleville.

"The Forest Insect Survey in 1940"—A. W. A. Brown, Division of Entomology, Ottawa.

"Note on Gross Estimate of Forest Insect Damage in Canada"—A. W. A. Brown, Division of Entomology, Ottawa.

"The Work of a Forest Insect Ranger"—H. S. Fleming, Division of Entomology, Ottawa.

"The Feeding Habits of Certain Leafhoppers"—W. L. Putman, Dominion Entomological Laboratory, Vineland Station, Ontario.

"Tobacco Insects of Canada"—G. M. Stirrett, Dominion Entomological Laboratory, Chatham.

"Feeding Habits and Movements of Third Year Grubs of *Phyllophaga anxia* Lec. in Central Ontario"—G. H. Hammond, Division of Entomology, Ottawa.

"Some Preliminary Experiments on the Insecticidal Value of Certain Plant Extracts, More Particularly Those of *Delphinium brownii*"—H. T. Stultz and N. A. Patterson, Dominion Entomological Laboratory, Annapolis Royal, N. S.

"Field Experiments in the Control of the Mullein Leaf Bug, *Campylomma verbasci* Meyer, in Nova Scotia Apple Orchards"—A. D. Pickett, N. A. Patterson and M. E. Neary, Dominion Entomological Laboratory, Annapolis Royal, and J. M. Cameron, Department of Agriculture, Nova Scotia.

"Experiments on the Control of the Strawberry Weevil"—Paul Morisset, Plant Protection Service, Quebec.

"Control of the Columbine Borer, *Papaipema purpurifascia* G. & R. with Additional Notes on its Biology"—W. G. Matthewman, Division of Entomology, Ottawa.

"The Garden Centipede, *Scutigerella immaculata*, as a Pest of Greenhouse Crops in Ontario"—G. G. Dustan, Vineland Station.

"Some Observations on Ticks in Eastern Canada"—C. R. Twinn, Division of Entomology, Ottawa.

PRESIDENTIAL ADDRESS

By Georges Maheux,

Director, Plant Protection Service, Quebec.

Every organized group of men, and professional associations are no exception, sooner or later acquires some traditions. By virtue of time these traditions become more respectable year after year, until a moment comes when nobody dares modify them. They acquire the force of law. Last year I was reminded by our devoted secretary that there was in this society an unwritten rule, or a sort of sacred habit, compelling the president to deliver an address at the opening session of each annual meeting. Being a law-abiding citizen by nature and education, I respected this tradition by giving you, at that time, a brief review of the development of economic entomology in Quebec.

This year I could have found many good reasons, or apparently acceptable excuses, to avoid preparing even a short address, such as the customary "pressure of work", or a "programme already sufficiently heavy without adding to it", and in my personal case, imperfect knowledge of the English language; but I thought that in these critical days, whatever position one may occupy, one must do his duty. Consequently, I felt the president should give, right at the outset of this convention, a good example instead of a bad one. Bounded therefore by this moral obligation, there will be, and you will have to hear, a short presidential address.

First of all, let us express our deep satisfaction that we are able to hold this meeting in spite of the troubled situation reigning in Canada and the world. We meet here to discuss technical problems having to do with the welfare of the country, while large groups of young Canadian soldiers have crossed the sea and are gallantly doing their share to defend one of the most precious privileges of mankind, liberty; liberty so ruthlessly attacked by a new form of tyranny and despotism. We are still permitted to enjoy here, in this Canada of ours, freedom of thought. May God give our armies victory and with it restore freedom in all enslaved countries and grant the world an everlasting peace!

We are privileged to meet once more in this magnificent institution of learning which holds such a high rank among Canadian and American agricultural colleges. Here, at Guelph, we find a college entirely devoted to the teaching of agriculture and already renowned as one of the best agricultural research centers on this continent. Besides, we entomologists remember Guelph as the birth place and permanent headquarters of this society. We meet here friends of high standing, masters in the various fields of science and, at the same time, we again enjoy the charming and ever renewed hospitality that has been tendered the members of this society, from time to time, for over three quarters of a century.

I heartly welcome at this meeting many distinguished visitors from the great American Republic which is united to Canada not only by geographical conditions but also by strong links in all fields of human activity; links becoming stronger by the association of two democratic peoples for their common defence. Your presence here affords a new proof that the boundary south of us does not exist in scientific circles, rather is it a mere dotted line on the map for this brotherhood of North American Entomologists. Let us hope you will enjoy your short visit in Canada as much as we find pleasure and inspiration in attending your conventions.

On account of its venerable age—this is the seventy-seventh annual meeting—our society holds an enviable place among entomological associations on this

continent. In the list of members, the names of a few pioneers are still present. During my 24 years as member of this society, I have seen it grow steadily. New members join us every year adding the strength and enthusiasm of youth to the experience of older members. After many scores of years spent in the service of their country, some of the elders take a well deserved rest, but, even in their retirement from official work, we know very well they will continue to faithfully serve the sacred cause of science and Canada. Their example will still inspire and guide us.

With these remarks I open the 77th annual meeting of the Entomological Society of Ontario. I hope this convention will be a very successful one.

SPRAYING FOR THE CONTROL OF THE EUROPEAN CORN BORER IN SWEET CORN*

by

GEO. M. STIRRETT, *Dominion Entomological Laboratory, Chatham, Ontario*

and

R. W. THOMPSON, *Ontario Agricultural College, Guelph, Ontario*

The object of the experiments described in this paper was to ascertain the performance, under Ontario conditions, of certain promising insecticides which had been used against the European corn borer, *Pyrausta nubilalis* Hbn., in sweet corn in the United States. Previous tests made by the staff of the Dominion Entomological Laboratory at Chatham in 1931 gave results which indicated poor control with the spray materials then available. Much progress, however, has been made with this problem by the entomologists of the United States, and newer sprays have given good results.

The problem was discussed with W. A. Baker, Senior Entomologist in charge of European corn borer Investigations of the United States Bureau of Entomology and Plant Quarantine, Toledo, Ohio. Since it was not possible to devote sufficient time to this problem to include any but the most promising insecticides tested by Mr. Baker and his staff, only two were recommended for trial in Ontario, namely, derris and cryolite.

Outline and details of experimental work.—Experimental plots were laid out at Chatham and at Guelph. They were to be treated, in so far as possible, in an identical manner. Golden Sunshine corn seed, from the same source, was planted at Chatham on June 3, and at Guelph on June 1, 1940. The lateness of these plantings was occasioned by extremely wet weather which delayed all crop seeding during the season. Sweet corn for the early market is planted much earlier in these districts in normal seasons. The planting distance in each case was 3 feet within the rows and 3 feet between rows. At Guelph, the experimental area consisted of 24 plots, while at Chatham, 48 plots were used. Each plot contained 120 hills, being 10 hills wide by 12 hills deep. The two outer rows on each side of a plot made up the buffer rows which were sprayed, but not used in taking the results. Two buffer rows were considered sufficient to offset any discrepancies which might result from larval migration.

Six treatments were under test; a derris spray at two rates of application, a cryolite spray at two rates of application and two check plots which received no treatment. Each treatment was replicated four times in the Guelph plots and eight times in the plots at Chatham. The arrangement of plots at Guelph is shown in Figure 1 and those at Chatham in Figure 2.

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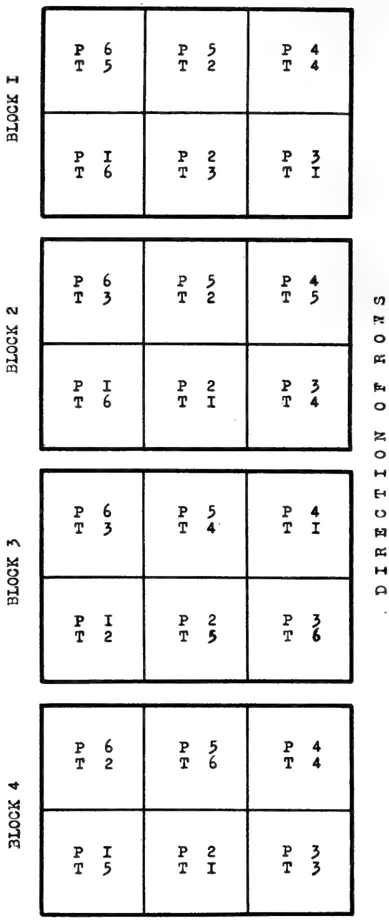
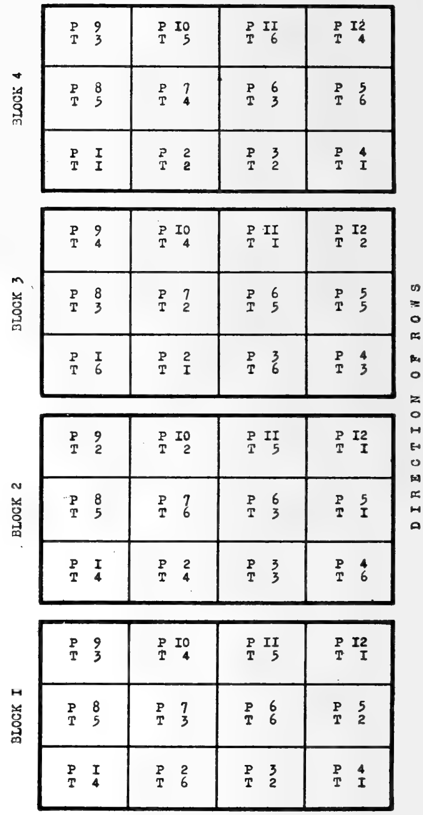
*Contribution No. 2046, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Dr. Geoffrey Beall of the Dominion Entomological Laboratory, Chatham, fitted the experimental plan to the two fields used and drew up the randomization of treatments into plots and blocks. Dr. Beall also made the randomizations of hills within plots used in taking results in the Chatham experiments.



PLOT : IO rows of I2 hills each
Spaced 3 feet each way
TREATMENTS
T I Derris, 2 applications
T 2 Derris, 5 applications
T 3 Cryolite, 2 applications
T 4 Cryolite, 5 applications
T 5 Check
T 6 Check

Fig. 1. Diagram of corn spraying experiments, Guelph, Ontario, 1940.



PLOT : IO rows of I2 hills each. Spaced 3 feet each way

TREATMENTS
T I Derris, 2 applications
T 2 Derris, 5 applications
T 3 Cryolite, 2 applications
T 4 Cryolite, 5 applications
T 5 Check
T 6 Check

Fig. 2. Diagram of corn spraying experiments, Chatham, Ontario, 1940.

The derris spray consisted of 2 pounds of ground derris root (4% rotenone), 4 ounces of Areskap, a commercial spreader, and 40 gallons of water. The cryolite spray consisted of ½ pound of synthetic cryolite, 1 pound of Volclay bentonite and 40 gallons of water. All sprays were applied with Hardie, 10-gallon, barrow-type, hand sprayers. These machines are capable of developing about 80 pounds pressure. At Guelph, the amount of spray applied per acre was considerably more than that used at Chatham, the respective amounts being 320 gallons of

spray per application at Guelph and 142 gallons at Chatham. From the results obtained in the Chatham plots it is apparent that the amount of spray used in the Guelph plots represents an excess of material. In applying the sprays, the object was to direct the liquid into the whorl of the corn plant. Later in the season tassels were also given special attention. During the operations, the leaves were of necessity fairly well covered.

Starting dates for spraying were based on slightly different criteria at the two experimental locations. At Chatham, a daily search for eggs was made well in advance of egg-laying time and continued throughout the season. Spraying was started within three days of the time the first egg masses were observed. At Guelph, where egg-laying was almost two weeks later than at Chatham, careful observations were made of the earliest egg masses, and, when these began hatching, the first spray was applied. The first spray was applied at Chatham on July 12 and at Guelph on July 26. The dates of application for the ensuing sprays at Chatham were July 17, 22, 27 and August 1. At Guelph, the remaining sprays were applied July 31, August 6, 12 and 17. Treatments receiving only 2 applications were sprayed on the first two dates indicated at each location, while 5 application treatments received sprays on all dates. Egg-laying during the 1940 season commenced about ten days later than usual at Chatham, and probably also at Guelph. The average date of commencement of oviposition at Chatham is July 2. The sprays were applied at five-day intervals; the interval of five days being used so that in the five-application treatments the fresh insecticide would be present over a slightly longer period than the twenty-one day period of egg-laying, common to the corn borer.

In spite of the fact that derris is adversely affected by exposure to light, it appears that in the whorls of leaves, characteristic of the young corn plant, sufficient protection from light exists for derris to remain effective against the small borers for a period of at least five days. In older plants, the spray collects in the axils of the leaves and it would appear from the results obtained that derris is similarly protected from light in these locations.

A sample number of hills were taken in which the number of larval free ears (ear infestation) and the reduction in borer population in the corn plants for each treatment was obtained. The methods used at Chatham differed somewhat from those used at Guelph. In sampling, at Chatham, three hills from each plot in the eight replicates were taken at random, at the time of first commercial picking and again when the corn was ripe (second commercial picking). At Guelph, the plots proper (192 hills per treatment) were picked completely in two pickings as they would be under ordinary commercial conditions. Larval counts (reduction in borer population) were taken later in the season by dissecting the corn plants in the samples. These examinations were made on September 13 at Chatham and on October 3 at Guelph.

Results of experimental work.—The results obtained in the two locations are summarized for the Guelph plots in Table I and for Chatham in Table II. The tables show the records for the samples taken and not the yield per acre.

At Guelph, the spray applications, whether of derris or synthetic cryolite gave an increased number of borer free ears above that obtained in the untreated check plots. Five applications gave slightly more borer free ears than did two applications of either material. Both synthetic cryolite sprays considerably reduced the number of ears the corn plants produced. The results at Chatham are very similar to those obtained at Guelph. Here again, both sprays at the two and five application rate gave an increased number of borer free ears. The cryolite sprays also markedly reduced the number of ears.

TABLE I. SUMMARY OF RESULTS OF EXPERIMENT ON THE CONTROL OF THE EUROPEAN CORN BORER ON SWEET CORN

Guelph, Ontario, 1940.

Based on a sample of 192 hills for each treatment

I. Ear infestation records

Treatment	1 Derris 2 Applic.			2 Derris 5 Applic.			3 Cryolite 2 Applic.			4 Cryolite 5 Applic.			5 Check (None)			6 Check (None)		
	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears
1st commercial picking, Aug. 20, 21, 22.	197	193	98	203	201	99	172	168	98	160	157	98	226	188	83	280	240	86
2nd. commercial picking, Aug. 29, 31, Sept. 3.	580	557	96	572	560	98	460	425	92	438	428	98	558	469	84	502	406	81
Totals	777	750	97	775	761	98	632	593	94	598	585	98	784	657	84	782	646	83

II. Reduction in borer population

Treatment	1 Derris 2 Applic.	2 Derris 5 Applic.	3 Cryolite 2 Applic.	4 Cryolite 5 Applic.	5 Check (None)	6 Check (None)
% reduction in larvae, Oct. 3	87	97	86	93	None	None

TABLE II. SUMMARY OF RESULTS OF EXPERIMENT ON THE CONTROL OF THE EUROPEAN CORN BORER ON SWEET CORN

Chatham, Ontario, 1940.

Based on a sample of 24 hills for each treatment

I. Ear infestation records

Treatment	1 Derris 2 Applic.			2 Derris 5 Applic.			3 Cryolite 2 Applic.			4 Cryolite 5 Applic.			5 Check (None)			6 Check (None)		
	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears	Total no. ears	No. ears uninfested	% larval free ears
1st. commercial picking, Aug. 16	157	126	80	167	161	96	136	112	82	132	125	95	169	121	71	162	112	69
Residual picking, Sept. 12	51	40	78	56	54	96	50	48	96	59	56	95	58	42	72	65	52	80
Totals	208	166	80	223	215	96	186	160	86	191	181	95	227	163	72	227	164	72
	II. Reduction in borer population																	
% reduction in larvae, Sept. 13	56			91			73			86			None			None		

In the plots sprayed with synthetic cryolite, there was a marked yellowing of the foliage within three days of the application of the first spray. This condition persisted throughout the season. The reduction in the number of ears produced by cryolite sprayed plants was 15 per cent at Chatham and 21 per cent at Guelph below the yield of the check or untreated plots. No injurious effects from the derris applications were noted. The yield in derris sprayed plots was about equal to that of the check plots in both locations.

The amount of reduction in borer population does not give an adequate idea of the worth of the spray treatment from a commercial standpoint.

Since the expense for spray materials at Guelph would be high if calculated on the basis of the gallonage applied, the monetary considerations in spraying have been calculated on the basis of the Chatham experiments. The cost of applying the sprays including labour at 25 cents an hour, cryolite at 14 cents a pound, Volclay bentonite at 5 cents a pound, Areskap at $1.00 a pound and derris at 40 cents a pound is shown below. With the sprayer used and water available at the edge of the corn field, it took two men ten hours to spray one acre. To apply the derris mixture for two applications, it costs $17.36 and for five applications, $43.40 per acre. The cryolite mixture costs $10.86 for two applications and $27.15 for five applications per acre.

The Guelph plots were sprayed excessively and planted thinner than usual, while the Chatham plots were planted thicker than is the usual custom. However, by using the results of the Chatham plots in regard to the percentage of borer free ears obtained from each treatment and the percentage reduction of ears in those plots damaged by spraying them with synthetic cryolite and applying them to the average normal yield of sweet corn in the district, a close approximation can be obtained of the monetary value of each spray treatment.

Normally, sweet corn is planted at the rate of 4,840 hills per acre (3 x 3 feet), 4 plants to a hill, and on the average each plant produces 2 marketable ears. This would give 38,720 ears of corn per acre.

In the check or untreated plots, Treatments 5 and 6, 72 per cent of the ears were free of borers, while in Treatments 1 and 2, 80 and 96 per cent, respectively, were borer free. In Treatments 3 and 4, 86 and 95 per cent were free of borer, but there was a 15 per cent reduction of ears under the yield of check plots caused by the spray. Thus, each treatment when calculated on the normal yield per acre for the district would produce the following number of borer free and hence marketable ears, in dozens per acre. The gain in number of dozens of borer free ears over check plot yield is also indicated.

Treatment No.		*Total no. borer free ears in dozens*	*Gain in borer free ears over check plot yield of borer free ears in dozens*
1	Derris, 2 applic.	2581	258
2	Derris, 5 applic.	3098	775
3	Cryolite, 2 applic.	2359	36
4	Cryolite, 5 applic.	2606	283
5	Check (untreated)	2323	......
6	Check (untreated)	2323	......

The net profit or loss per acre for each treatment is shown below for three prices at which ear corn could be sold. Naturally, the higher the price obtained for the crop, the larger the returns from the spray application.

TABLE III—SHOWING NET PROFIT OR LOSS PER ACRE IN DOLLARS OBTAINED FROM THE USE OF EACH TREATMENT WHEN BASED ON THE NORMAL AVERAGE YIELD OF THE DISTRICT; THE RESULTS OF SPRAYING EXPERIMENTS AT CHATHAM, ONTARIO, AND THE COST OF SPRAY APPLICATION INDICATED IN TEXT

Treatment No.		*Price obtained for crop per dozen ears*		
		.30	*.20*	*.10*
1	Derris, 2 applic.	$60.04	$34.24	$ 8.44
2	Derris, 5 applic.	189.10	111.60	34.10
3	Cryolite, 2 applic.	-.06	-3.66	-7.26
4	Cryolite, 5 applic.	57.75	29.45	1.15

Treatment 2, five applications of derris, gave the largest number of borer free ears and hence, the largest monetary gains from spraying. If corn was sold at the low rate of ten cents per dozen ears, this spray still enabled the grower to make a net profit of $34.10 per acre. Fair returns were obtained from Treatment 1, two applications of derris, as long as the selling price was fairly high. Treatment 3, which was two applications of synthetic cryolite spray, showed a considerable loss of revenue because the cryolite reduced the number of ears produced. Treatment 4, which was five applications of cryolite, markedly reduced the yield of ears, but gave such a high percentage of borer free ears that this disadvantage was overcome and a profitable return would be obtained by the grower as long as the price of the corn was high.

Because of the damage to the plant from the use of synthetic cryolite, it would not be wise to recommend this material for spraying sweet corn.

Conclusions.—All spray applications gave an increase in the number of borer free ears. The sprays also gave reductions in borer populations.

All of the sprays used with the exception of two applications of cryolite show profits; five applications of derris spray was the most profitable.

Despite the injury to the corn by yellowing of the leaves and reduction in the number of ears, five applications of cryolite were still profitable if twenty cents or more per dozen ears was obtained for the crop.

Synthetic cryolite, at the rates used, injured the plant to such an extent that it cannot be recommended for use on sweet corn.

In years of heavy borer infestation such as might be expected from weather duplicating that occurring this season, early corn pickings of marketable ears could be attractively increased by spraying.

In the check plots at Chatham, the ear infestation was approximately 28 per cent and the grower would have to spend considerable time sorting out the borer infested ears before marketing the crop. All sprays gave such a high percentage of borer free ears that this would not be necessary.

The sprays give an individual grower considerable independence of the type of clean-up done by his neighbours. Purchased co-operatively, the spray materials would perhaps be obtainable at lower prices and could be adopted as control measures by canning concerns.

Acknowledgements.—Suggestions received from W. A. Baker of the United States Bureau of Entomology and Plant Quarantine have already been acknowledged. The work of randomization done by Dr. Beall has also been mentioned. The actual work of laying out plots, applying sprays, taking egg counts and taking results of experiments was done at Chatham by members of the laboratory staff, including Doctors Geo. M. Stirrett and Geoffrey Beall, Messrs. D. A. Arnott, A. A. Wood and H. B. Wressell. The work at Guelph was carried out by Professor R. W. Thompson and Messrs. G. E. Coppel, A. G. McNally, H. W. Goble and R. K. Chapman, all of the Department of Entomology, Ontario Agricultural College.

HYBRID CORN IN THE CORN BORER CONTROL PROGRAM, WITH NOTES ON THE SITUATION IN ONTARIO IN 1940

By R. W. Thompson, *Ontario Agricultural College, Guelph.*

For four years tests have been conducted in Ontario to determine the value of a number of the more promising hybrid corn strains in comparison with standard varieties of corn grown here for a good many years. At two previous meetings of this society the results obtained in fairly large scale tests were reported. Results obtained this year bear out a feeling on the part of the writer and expressed by some other workers, that the tests are more valuable in showing the performance of the hybrids than they are in demonstrating borer resistance amongst such strains. Certain strains have had small borer populations throughout three seasons differing widely in weather conditions. This season (1940) there has been a marked increase in corn borer abundance in all of the varieties and strains included in the tests. As a result the number of borers per 10-stalk sample was three to five times as large as in 1938. This condition is general for both the Guelph and the Ridgetown plots.

The number of varieties and strains tested this year at Guelph was 60 in comparison with last year's total of 61. At Ridgetown 53 were tested this year compared with 56 last year. Full agronomic data have been collected by the college Department of Agronomy for the same length of time as records have been made of borer populations. The experiments were directly under the supervision of the above-mentioned department and this explains why the same hybrids have not been used in the tests in each of the three years. In some instances, after trial for one year, certain of the hybrids were found totally unsuitable for use under Ontario conditions and were therefore replaced by other strains which appeared more promising from an agronomic standpoint. It is obvious that, whatever qualities a strain possesses from a borer resistance standpoint, these would be of small account if the strain were a failure when considered from a production standpoint. As has been emphasized in previous reports, our tests were not solely tests for borer resistance but rather a hopeful endeavour to find strains which would give increased yields and at the same time help to directly decrease the borer by resistance or to aid in combating the pest by tolerance of it.

The same plot technique and method of determining borer populations have been followed each year of the tests. Borer populations are again reported on the basis of the average number of borers in 10 stalks taken at random and dissected from each variety and hybrid strain in two replicates at each experimental location. There was no storm damage or stalk breakage caused by strong winds this year at either Guelph or Ridgetown. The small amount of stalk breakage which did occur, therefore, is attributable to corn borer feeding. In view of the small amount of stalk breakage throughout the plots it has been considered unnecessary to include a table showing comparative stalk injury.

In Table I the average number of borers per 10 stalks at Guelph is shown for each of the varieties and hybrid strains included in the test plots in 1940. Figures for 1939 and 1938 are also given where the variety or strain was included in tests conducted during one or both of those years. In 1938 the borer populations found in hybrid strains generally were considerably smaller than those occurring in the popular open-pollenated varieties. Dry weather in 1939, with its consequent effect upon both the corn borer and its host plant, reduced the contrast in borer populations which had resulted between hybrids and standard varieties in the 1938 tests. In 1940 there has been a marked increase in corn borer abundance throughout most of Ontario and in keeping with this there have been markedly larger populations in nearly all of the corns included in our tests. Moreover, at

Guelph, as can be seen from Table I, a number of the hybrids had larger borer populations this year than occurred in the standard varieties. Further examination will show, however, that some of the hybrids have had reduced borer populations throughout all three years of testing. Among these are some of the hybrids demonstrating the better agronomic characteristics. There is a small amount of stalk breakage in some of the hybrids where the larger borer populations occurred, but not sufficient to cause much loss in harvesting since most of the breakage occurred above the cob-shank.

TABLE NO. 1

AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, GUELPH, 1938, 1939 & 1940

Variety or Strain	*Borers*			*Variety or Strain*	*Borers*		
	1938	*1939*	*1940*		*1938*	*1939*	*1940*
Wisconsin 460			87	Hybrid 353 L.F.			62
Funk's Hybrid G-6			86	Hybrid 370 M.F.			61
Funk's Hybrid G-5			85	Longfellow	21	42	61
Wisconsin 531	16	31	84	Hybrid F.K.			60
Wisconsin 455		25	82	Dellinger			58
Hybrid 357 L.F.		31	80	Hybrid L 4	11	32	58
Minnhybrid 402	19	29	77	Que x Lanc.			57
Hybrid D		27	76	Salzer's N.D.	15	42	56
Wisconsin 572		35	75	Golden Glow Cohoe	18	30	56
Hybrid 240			75	Hybrid K.N.			56
Hybrid G-15-2			74	Wisconsin No. 7	20	21	55
Hybrid 404			74	Hybrid K 23			54
Golden Glow Stewart	23	28	74	Hybrid 322 L.F.			54
Minnhybrid 401	23	30	72	Hybrid 202 D.K.	13	32	53
Hybrid 324 L.F.			70	W.C.Y. Dent		33	53
Hybrid 355 M.F.			69	Wisconsin 570		25	52
Minnhybrid 301	15	31	68	Wisconsin 606	14	18	52
Hybrid E2	15	35	68	Wisconsin 646		15	52
Cornell Hybrid 29x3	18	36	68	Compton's Early	17	20	50
Wisconsin 525	18	35	67	Wisconsin 603		16	50
Wisconsin 415			67	Wood's H.Y.S.		33	50
Hybrid M.		25	66	Golden Glow Smith	14	25	48
Stowell's Evergreen		13	65	West Branch Sw.	19	27	48
Excelsior	18	36	65	Hybrid F.B.	10	24	48
Hybrid K 35	20	33	65	Wood's H.Y.D.		23	47
Hybrid G-12-2			64	Hybrid G-17		27	47
Minnhybrid 403		34	64	Hybrid Ill. 751	8	31	47
Wisconsin 645	13	21	63	Wisconsin 625	11	30	47
Hybrid G-7-2		19	63	Wisconsin 620	12	32	47
Hybrid 355 S.F.		28	62	Burr Leaming		33	45

In Table 2 the average number of corn borers per 10 stalks in standard variety and hybrid corns in the Ridgetown plots is shown. As in Table 1, those varieties and hybrids which are common to the two or three years are shown for 1939 and 1938. It will be noted from the 1940 figures that three of the standard varieties of corn show the highest borer populations. At Ridgetown a different group of hybrids is included in the small borer population levels than that which comprises the Guelph group. In general the hybrids show smaller borer populations in the Ridgetown plots than do the standard varieties.

From the figures shown in both tables it will be seen that resistance to borer is difficult to demonstrate, despite the fact that some hybrids do show small borer populations throughout the three years of testing. A more outstanding character-

istic demonstrated by the hybrids in all but a very few cases is that of greater stiffness or sturdiness of stalk in comparison with the weaker stalks of the standard varieties. The hybrids are thus better able to withstand storm and heavy winds. This season many of the hybrids have demonstrated their ability to remain erect despite the presence of a large number of borers. This characteristic of stiffness of stalk is of prime importance in harvesting and, given strains which produce grain equal in quantity and quality to our standard varieties, the hybrids should harvest more corn per acre than standard varieties which become badly broken

TABLE NO. 2

AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, RIDGETOWN, 1938, 1939 & 1940

Variety or Strain	*Borers*			*Variety or Strain*	*Borers*		
	1938	*1939*	*1940*		*1938*	*1939*	*1940*
Longfellow	19	23	72	Hybrid 322 L.F.			38
Wisconsin No. 7	20	14	71	Wisconsin 696	28	8	38
Salzer's N.D.	18	13	71	Minnhybrid 401		18	38
Hybrid G-12-2		13	70	Hybrid T		3	37
Hybrid 355 M.F.			65	Wisconsin 603		13	37
Hybrid F.B.		7	63	Hybrid 202 De Kalb	15	5	37
Minnhybrid 301	12	7	63	Iowealth Hyb. A.Q.		5	36
Hybrid 357 L.F.			62	Hybrid 355 S.F.		6	35
Hybrid F.K.		7	57	Iowealth Hybrid A.P.		5	35
Minnhybrid 402		8	56	Hybrid K 35	17	10	34
Hybrid 240 D.K.			54	Hybrid G-17		12	34
Hybrid 324 L.F.			53	Golden Glow Cohoe	16	14	34
Wisconsin 625	16	8	52	Wisconsin 620	16	9	33
Wisconsin 678		13	49	Wisconsin 646		5	33
Compton's Early	11	17	48	Hybrid G-7-2		7	32
Iowa 939			48	Minnhybrid 403		10	31
Wood's H.Y.S.		16	47	Wood's H.Y.D.		8	29
Cornell Hybrid			46	Hybrid Ill. 751	23	7	28
Golden Glow Smith	9	7	46	Wisconsin 676		7	26
Wisconsin 695		13	46	Wisconsin 690			25
Wisconsin 645	25	6	45	Hybrid L-4	12	17	25
Iowealth Hybrid 16			42	Hybrid G-15-2		10	24
Wisconsin 680	7	11	42	Wisconsin 570	11	12	23
Hybrid M		7	42	Wisconsin 606	9	7	22
Hybrid 404			41	Wisconsin 531			22
Hybrid K 23	22	9	40	Dellinger			21
Illinois 366			38				

down and twisted prior to harvest. Moreover, it is easier to dispose of crop refuse subsequently if the crop remains standing erect at the time of harvest, because stubble in such a case can be cut shorter and thus more easily buried by ploughing. In Essex and Kent counties particularly, and to a lesser extent in other counties of the province, this season, fields of hybrid corn have in many cases enabled growers to harvest larger corn crops than would have been the case had all such fields been planted to standard varieties of corn and been broken down in the normal manner by large borer infestation. Thus, while our results have not shown a clear demonstration of resistance to corn borer in the hybrid strains in all three years, from them we can derive some idea of hybrid performance during years of different borer abundance.

As regards the general situation in Ontario this year, from the standpoint of borer infestation, the figures shown in Table 3 indicate the large increase in borer abundance. Stalk infestation counts which have been made in the province since

TABLE NO. 3

AVERAGE PERCENTAGE OF STALKS INFESTED BY CORN BORER

COUNTY	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Brant	10	16	15	10	....	7	15	15	....	3	4	19	....	25	63
Durham	....	6	....	21	12	11	....	....	9	17	15	18	27	....	49
Elgin	48	37	24	21	9	17	23	17	7	18	16	25	50	40	70
Essex	83	65	42	36	17	28	28	30	9	20	32	47	34	29	68
Haldimand	4	30	12	8	....	....	....	....	6	4	6	15	....	....	62
Halton	....	....	....	9	12	13	12	17	11	8	15	7	20	....	57
Hastings	....	....	....	10	27	13	....	....	....	....	25	13	....	....	....
Huron	11	17	12	16	....	....	....	28	....	14	....	16	....	....	46
Kent	70	49	35	21	22	27	29	35	6	24	20	44	42	34	73
Lambton	34	57	21	14	7	....	35	23	8	21	20	31	41	38	81
Lennox	.5	2	12	22	33	27	19	18	....	....	46	18	....	....	....
Lincoln	5	43	30	11	9	11	13	20	5	4	12	6	....	5	39
Middlesex	29	36	18	10	9	15	22	20	5	6	14	22	34	33	64
Norfolk	16	10	20	6	5	5	11	9	3	9	4	30	26	27	70
Northumberland	....	....	....	18	16	8	....	....	5	....	15	13	....	....	41
Ontario	....	....	....	9	4	5	....	....	15	17	23	19	21	....	50
Oxford	31	14	15	18	....	13	16	17	6	17	19	34	29	38	70
Peel	....	....	10	19	17	22	29	39	11	12	12	11	....	....	63
Pelee Is.	....	....	15	24	5	6	7	12	4	9	13	22	13	17	26
Perth	....	8	9	16	....	....	....	6	....	12	....	20	....	45	64
Prince Edward	....	....	18	21	28	17	....	....	....	44	27	22	....	....	....
Waterloo	....	....	8	5	....	....	13	11	....	7	....	12	....	25	66
Welland	24	41	26	5	14	10	....	7	2	4	4	16	12	....	35
Wellington	....	....	....	8	5	....	9	....	....	7	10	3	....	....	65
Wentworth	....	22	25	9	13	8	17	19	8	6	7	12	17	21	39
York	....	....	....	....	....	5	22	....	....	16	8	28	....	....	68

1926 were extended this fall to include all of the counties in which corn borer clean-up regulations are in effect. In addition, counts were also made in Ontario county which, although not included in the list of counties where clean-up was enforced, is situated between York and Durham counties where regulations are in effect. The area, then, from Windsor to the eastern border of Northumberland county was examined this fall. In nearly all of this area the percentage of infested stalks in 1940 is double or treble that of 1939. In areas outside of this territory many people have experienced serious loss this year from borer damage for the first time on record.

The members of this society will recall that on several occasions Professor Caesar stated that if we had three years in succession which were favourable to the borer we must expect an increase in abundance of the insect in spite of good clean-up of refuse. There is no doubt that this has been an exceptionally favourable year for the borer and in some parts of the province was the third year in succession when weather conditions were favourable to the insect.

The clean-up in the area where regulations are in effect was reasonably well done this spring, although it was difficult to maintain the standard set in some previous years, because of the extremely wet weather. There was not sufficient difference in the standard of clean-up, however, to account for the large increase in the numbers of the insect.

Sweet corn growers and canning factories were particularly affected by borer damage this year. Cobs were heavily infested and thus a big increase in labour for the sorting and treating of these was necessitated. In addition, sweet corn was planted on dates which more closely coincided with early field corn and as a result the fields of sweet corn were more attractive than has been the case for several years.

In spite of the big increase in borer abundance there is by no means the extensive damage to corn in Kent and Essex counties which occurred in 1926 and 1927 when the corn crop was seriously threatened with complete destruction.

FEEDING HABITS AND VERTICAL MOVEMENTS OF THIRD YEAR GRUBS OF *PHYLLOPHAGA ANXIA* LEC.*

By

G. H. Hammond, *Division of Entomology, Ottawa*

The marked reduction both in the duration and intensity of attack of third year white grubs on agricultural crops has been observed for many years. The feeding habits and migrations of third instar, third year white grubs, especially as these bear on control processes of various types, are imperfectly known. To illuminate the problem studies were incepted in 1940 in Hastings county where the population of third year white grubs was determined as averaging 4.33 individuals per sample (2.25 square feet) 17.32 per square yard, or 83,828 per acre. Depth determinations made at intervals of about 5 days from May 7 to October 14, revealed the fact that while a limited number of third year grubs migrated to near the soil surface during the later part of May the great majority remained at a considerable depth, not far removed from the levels at which they hibernated,

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TABLE I

Depths at which various stages of third year June Beetles occurred, Season 1940, Marmora, Ont.

Period 1940	No. of Samplings	Depth in inches									Total
		0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	
May 7-22	4	4	35	119	188	157	77	28	9	1	618
						%99.35					
May 27 — June 15	4	119	139	299	226	79	16	4	0	0	882
						%87.64					
June 19 — July 9	5	30	68	136	136	80	19	3	0	0	472
						%92.79					
July 9 — Aug. 28	7	20	177	253	238	168	39	3	0	0	898
						%97.66					
Sept. 4-18	2	2	20	49	40	37	18	4	0	0	170
						%98.23					
Oct. 14	1	0	6	20	21	21	11	1	1	0	81
						%100					
May 7 — Oct. 14	24	175	445	876	849	542	180	43	10	1	3121
	%	5.6	14.2	28.0	27.2	17.3	5.7	1.05	.3	.03	99.38
						94.26					
					72.5%						

a situation which threw new light on the matter of grub feeding and also the comparative amount of damage in the third year of the life cycle likely to be caused to agricultural crops.

It is usual to find that grubs in the process of feeding in sod are located at a depth of one inch. White grubs at or above two inches are considered to be in the feeding zone. The grubs at lower levels are regarded as not feeding at all. They are largely inactive apart from minor vertical movements, and pupate at depths in the soil close to the depth at which hibernation occured. A tabulation of the recoveries of white grubs throughout the season at various depths from time to time is presented in Table I. It indicates the depth at which the insects were found in the several stages present, third year grubs, pupae or dormant beetles for each period, in two inch levels. In the period of May 7-22 only four grubs were found in the 0-2 inch feeding zone out of a total of 618 examined. However, a sharp increase in numbers at this level occurred between May 27 and June 15 when 119 grubs were found near the surface out of a total of 882 studied. For the period of June 19 to July 9 the number and proportion of grubs at or above the 2 inch level receded sharply and this recession became much more marked toward the end of August, and no grubs occurred in this zone on October 14.

The study showed, also, that, taking the season as a whole, the great mass of these insects in the third year, 72.5 per cent, occurred between a depth of 4 and 10 inches. A distinct upward movement occurred during late May and early June. This was followed by some feeding of under-developed individuals which constituted somewhat more than 10 per cent of the population. 99.35 per cent of ali grubs were below the feeding level in the period of May 7-22. This proportion decreased to 87.64 per cent for the period of May 27 to June 15 and then increased steadily toward the end of August, reaching 100 per cent in October. For the season as a whole 2942 or 94.26 per cent out of a total of 3121 individuals were found below the two-inch level.

The grubs under study arose from the major flight of June beetles of 1938 which, after causing severe losses of crops during 1939 over a large part of Ontario entered the beetle stage during late summer and these will form a major flight again during 1941. It is interesting to note that few individuals found in the Hastings County area were developing as a brood peculiar to the local area. Second year white grubs encountered were too few to cause any material damage to crops during 1940 and the same will also be true in 1941. The next year of severe white grub damage in eastern, central and western Ontario will be 1942.

Third year grubs found this year in the two-inch level were active and obviously were feeding. Below that depth they were inactive and displayed little movement when dug from the soil. The majority of these at least remained in the pupal cell over a prolonged inactive period before pupation and pupated relatively early in the season. Those which came to the surface to feed formed a pupal cell at a later date. Pupation occurred at all depths at which grubs were found and the average depth of pupation approximates rather closely the average depth of third year white grubs during late spring and early summer.

The feeding period of third year white grubs is somewhat less than one month as compared with about four months for second year white grubs.

The maximum depth of ordinary ploughing is six inches and much is actually more shallow than this. Grubs, pupae or beetles below that depth are unaffected by cultural processes such as ploughing and discing.

As but a small proportion of the third year white grubs do any feeding, stomach poisons, used under the most favourable conditions, are likely to kill only a small proportion of the total grubs in the soil and are therefore not nearly so suitable for use as against first or second year white grubs.

FIELD EXPERIMENTS FOR THE CONTROL OF THE MULLEIN LEAF BUG *CAMPYLOMMA VERBASCI* MEYER, IN NOVA SCOTIA APPLE ORCHARDS[1, 2].

By

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and

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A previous report (1) described the history of the mullein leaf bug, *Campylomma verbasci* Meyer, and its activities in Nova Scotia to the end of 1938. Following the very serious outbreak of that year the insect appeared to be almost non-existent in 1939. A close watch in apple orchards which had been heavily infested in 1938 and also of other host plants, including mullein, showed very clearly that there had been a great reduction in population. No injury to apples of any consequence was recorded in 1939.

In 1940, there was again a fairly serious outbreak on apple. While the injury did not reach the proportions of that of 1938, it was nevertheless, substantial, some of the very susceptible varieties in a few orchards being practically a total loss.

Preliminary experiments carried on in 1938 showed clearly that the ordinary treatments of nicotine sulphate or pyrethrum powder, used to control the green apple bug, *Lygus communis* Knight and the apple red bug, *Lygidea mendax* Reut. are not efficient against the mullein leaf bug. These tests showed further that the failure of the commonly used spray treatments is due to lack of efficiency in wetting. With this in mind, field experiments were undertaken in three blocks of orchard during the summer of 1940, two of these being sprayed and the third dusted. The varieties concerned in all three blocks were Gano and Ben Davis. Since these are very similar except for color, and since both appear to be equally susceptible to attack by the mullein leaf bug, they have been treated as a single variety. In all cases the spraying was done under good weather conditions.

Table I shows the results obtained by spraying a block of twelve-year-old trees when in bloom. About six gallons of spray were used per tree and there were approximately twelve trees per plot.

Table II gives the results secured by spraying a comparatively large block of trees about fifteen years old. The plots were in quadruplicate, and every fifth row was left as a check so that there were eight check rows. The results given in all cases are averages of the replicate plots, which, it should be mentioned, showed little variation. Approximately eight gallons of spray per tree were applied and the treatments were made ten days later than those represented by table I, or about one week following petal fall.

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1. A cooperative project of the Dominion Entomological Laboratory, Annapolis Royal, N. S. and the Provincial Entomological Laboratory, Wolfville, N. S.

2. Contribution No. 2053, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Table I

Blossom Spray for Control of Mullein Leaf Bug.

Records of Bugs and Fruit Injury

Materials used	*Amts. per 100 gal.*	*No. of live bugs 3 days after treatment per 200 blossom clusters*	*Percent of fruit showing injury on July 19, based on approx. 200 apples*
Check (No treatment)		353	88.6
Nicotine sulphate	1 pt.		
Santamerse No. 1	1 lb. 3 oz.	122	52.2
Pyrethrum powder	3 lb.		
Santamerse No. 1	1 lb. 3 oz.	205	47.4
Flotation sulphur	15 lb.		
Pyrethrum powder	3 lb.		
Santamerse No. 1	1 lb. 3 oz.	187	46.7
Pyrethrum powder	3 lb.		
Santamerse No. 1	2 lb. 6 oz.	137	51.5
Pyrethrum powder	3 lb.		
Santamerse No. 1	10 oz.	222	71.6
Pyrethrum powder	3 lb.		
Red Drum spreader	2 pt.	158	40.0
Pyrethrum powder	4 lb.		
Santamerse No. 1	1 lb. 3 oz.	129	48.3
Pyrefume Super 20	1 pt.		
Santamerse No. 1	1 lb. 3 oz.	70	30.0
Berako	2 qt.	103	28.0
Nicotine sulphate	1 pt.		
Red Drum spreader	2 pt.	45	25.0

Table III shows the results obtained by dusting. The dust was applied under not too satisfactory weather conditions, two days after the sprays on the plots represented in Table II. The work was done early in the morning and there was a slight drift of dust through the trees from air currents.

In the application of dusts, the actual quantity of pyrethrum employed per tree was kept as constant as possible regardless of the amount of diluent used.

Discussion of Results

Due to the heavy winds during the autumn, the fruit in the orchard represented by table I was so badly stripped from the trees that it was not possible to get a record of the fruit at picking time, hence only the midsummer records are given.

A comparison of the results shown in tables I and II indicate that the later treatments were the more effective. This may be due to the protection afforded by the blossoms, among which the smaller nymphs could readily secrete themselves.

So far as the spray treatments are concerned, there were no very marked differences among the various plots. All plots treated showed a marked reduction in infestation compared to the checks. There is some indication that pyrethrum powder and pyrethrum extracts are more effective than nicotine. The results appear to indicate quite clearly that the efficiency of wetting is an important factor in the control obtained, regardless of the insecticide used. The rotenone spray Berako did not appear to give as good immediate results as did nicotine sulphate or pyrethrum but the injured fruit counts indicated that it possibly had a more lasting effect. This point needs further testing since the material was used only in a single plot, where, as shown by counts on the adjacent check tree, the infestation was lighter than in the rest of the orchard.

TABLE II

Post-Blossom Spray For Control of Mullein Leaf Bug.
Records of Bugs and Fruit Injury

Materials used	Amt. per 100 gal.	No. of live bugs 2-4 days after treatment per 400 blossom clusters	% of fruit showing injury July 23-25 based on 800 apples	At picking time, Based on 4000 apples
Check (No treatment)		277	68.6	29.8
Pyrethrum powder	3 lb.			
Santamerse No 1	1 lb. 11 oz.	34	31.3	9.3
Nicotine sulphate	1 pt.			
Santamerse No. 1	1 lb. 11 oz.	52	40.6	13.9
Nicotine sulphate	1 pt.			
Hydrated lime	10 lb.	70	47.1	15.5
Nicotine sulphate	1 pt.			
Orthex spreader	2 pt.	80	30.1	7.3
Pyrethrum powder	3 lb.			
Orthex spreader	2 pt.	60	25.3	9.9
Pyrethrum powder	4 lb.			
Orthex spreader	2 pt.	46	28.9	9.7
Pyrefume super 20	1 pt.			
Orthex spreader	2 pt.	21	28.9	8.9
Pyrefume super 20	1 pt.			
Santamerse No. 1	1 lb. 11 oz.	19	37.4	8.7

TABLE III

Dusting for Control of Mullein Leaf Bug.
Records of Bugs and Fruit Injury

Materials used	Parts per 100 lb. of materials	No. of live bugs 2 days after treatment per 200 blossom clusters	% of fruit showing injury July 23-25 based on 400 apples	At picking time, Based on approx 2000 apples
Check (No treatment)		102	74.3	32.7
Nicotine sulphate	5			
Hydrated lime	95	38	73.5	18.3
Pyrethrum powder	30			
Hydrated lime	70	11	57.3	15.4
Pyrethrum powder	30			
Walnut Shell flour	70	23	40.3	18.1
Pyrethrum powder	30			
Walnut Shell flour	69			
Santamerse D	1	13	44.5	17.5
Pyrethrum powder	99			
Santamerse D	1	19	45.5	18.3
Pyrethrum powder	100	18	50.5	18.5

It is believed that failure to get more complete control by spraying is due to the difficulty of completely covering all parts of the tree where the insect may be found.

In respect to the results from dusts as shown by table III, these did not appear quite so effective as the spray treatments. The spray treatments, however, were applied under more generally satisfactory conditions, and this may explain in part the results obtained.

The difference in the percentages of injured apples shown by the counts in July and those at harvest is believed to have resulted from the obliteration of slight injuries, visible in July, by the growth of the fruit later in the season.

REFERENCE

1. PICKETT, A. D. (1938).—The mullein leaf bug, *Campylomma verbasci* Meyer, as a pest of apples in Nova Scotia.—69th Ann. Rep. Ent. Soc. Ontario, pp. 105-106.

TWO EXPERIMENTS WHICH SHOW PROMISING CONTROL OF THE COLUMBINE BORER, *PAPAIPEMA PURPURIFASCIA* G. AND R., (PHALAENIDAE)*

By W. G. MATTHEWMAN, *Division of Entomology, Ottawa*

For the past five seasons, a study on the control of the columbine borer has been conducted at Ottawa, and the following two procedures have given very satisfactory results under experimental conditions: (1) Derris dusts applied to the columbine foliage and soil, as a larvicidal protective coating, during the hatching of the eggs; (2) transplanting of the columbines in the spring of the year, before the hatching of the eggs.

The study was primarily an investigation of ovicides—that is, of sprays and dusts applied to the soil surface in an attempt to kill the overwintering eggs. Thirty materials were tested in the laboratory, or on a small scale outdoors, and three, namely, ground derris and the proprietary thiocyanates, "Lethane" and "Loro" were shown to be highly toxic to the eggs and only slightly phytocidal. Unfortunately, the latter two insecticides proved ineffective in the field, since many of the eggs became buried in situations where they were inaccessible to spray solutions. Autumn and spring applications of rotenone dusts were 70-85 per cent effective, but only when the materials were applied in prohibitively large amounts. These studies were of interest from an ovicidal standpoint, but as far as control of the columbine borer was concerned, they proved to have little value; consequently this paper has been restricted to a description of the two methods which show decided promise.

Derris Dust as a Larvicide

Three seasons' tests have shown that repeated applications of a derris and talc dust during the period of hatching, will give excellent control of the columbine borer. The dust is applied to the soil surrounding the plants as well as to the foliage, and four applications at twice-weekly intervals are necessary to furnish the columbines with protection over a two-weeks' period. Actually, three applications are as effective as four if they are correctly timed, since once the larvae have gained entrance to the plants, further dusting is useless. In the work of 1940 the controls secured ranged from 89 per cent with a 1.0 per cent rotenone dust to 94 per cent with a 2.5 per cent dust, and when the rate of application with the latter dust was reduced by one-half, the percentage improvement over check was 86. The dusts were applied heavily, in increasing amounts as the foliage developed, at an average rate of 250 pounds per acre, but the cost of materials with a crop such as columbines usually is not considered on a "per acre" basis. With derris at the high price of 80 cents a pound and talc at 4 cents, the cost of an application of the 1.0 per cent dust would be 39 cents per 100 columbines.

Consistent results with derris applied as a larvicide have been secured for the past three seasons, although the experiments of 1938 and 1939 were conducted on a smaller scale than in 1940. The same procedure, in general, was followed in each year's tests. The columbines were grown from seed in a nursery, and when they had reached the desired size, they were transferred to the experimental plots where during the autumn, each plant was "seeded" with a definite number of eggs. Those eggs used in the control experiments were selected from 30 or more separate oviposition cages and had a hatchability of almost 100 per cent. While this method of procedure was artificial, it closely paralleled infestations which take place in

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nature and at the same time materially reduced the number of variable factors which usually are met with in the field.

In the 1940 experiment, eight treatments and a check were tested upon triplicate plots of columbines. Each of the 27 plots was 8 feet by 9 feet in size and was composed of 20 plants. During October, 1939, the columbines had been infested artifically with 13,500 eggs—500 per plot or 25 to a plant, and these eggs, when sampled in the spring, proved to have a hatchability of 96 per cent. The derris was of a good commercial grade assaying five per cent rotenone, and the diluent was talc. A cheesecloth bag was used in dusting and 4 applications were made on May 13, 17, 20 and 23 at 5, 6, 7 and 8 ounces per plot on the respective dates (¼ to 2/5 ounces per columbine, or 250 pounds per acre at each application). Hatching of the eggs commenced May 18 and was concluded before May 23, while dissection of the columbines for larval establishment was carried on June 5-21.

In Table I, the percentage control, or percentage improvement over check has been calculated by Abbott's formula (1925), and for this purpose it has been assumed that the potential number of borers established per plot was equivalent to the number of eggs set out, i.e. 500. On this basis, the percentage larval establishment in the three checks was 15.5.

Table I

Control of the Columbine Borer with Derris Dusts Applied as Larvicides, Ottawa, Ontario, 1940

Derris Dusts			Number of living borers a month after hatching				
Per cent rotenone content	Pounds applied per acre	Number of applications	Plot A	Plot B	Plot C	Total	Per cent control
2.5	250	3 semi-weekly	3	4	6	13	94.2
2.5	250	4 semi-weekly	1	6	11	18	92.2
1.6	250	4 semi-weekly	5	5	8	18	92.2
1.0	250	4 semi-weekly	5	9	12	26	89.0
2.5	125	4 semi-weekly	7	9	15	31	86.4
2.5	2 0	2 weekly	11	18	10	39	83.2
2.5	250	2 semi-weekly	13	24	27	64	72.2
2.5	250	1 only	26	18	43	87	62.5
Check (no treatment)			55	75	102	232	....

An examination of the figures in Table I suggests that without materially lessening the efficiency of the dusts, their rotenone content might be reduced from 2.5 to 1.0 per cent. Similarly the rate of application might be cut to 125 pounds per acre, but a further reduction probably would be undesirable. Even at 125 pounds per acre, the soil surrounding the columbines was coated with a film of dust, and it is possible that the larvae came into contact with the latter before they actually reached the plants. The significant point, however, is that there appears to be considerable leeway between the date of hatching and the timing of the applications. If the latter are reduced in number at least some control may be expected for, as indicated in the preceding table, a single application of the 2.5 per cent dust, made 5 or 6 days before hatching yielded a 62.5 per cent improvement over check—despite heavy rainfall. That derris will remain effective for some time in the field has been demonstrated before, but this experiment stresses the possibility of controlling certain other boring caterpillars with rotenone dusts owing to the persistence of their toxicity.

Timing of the applications would seem a difficult matter, for there appears to be no definite correlation between hatching of the eggs and development of the columbines. At Ottawa, commencement of hatching has varied over a range of 12 days in the past five seasons. However, four applications of the dusts appear to furnish the plants with continuous protection for a fortnight, and this period should compensate for normal yearly variations in any one locality. In eastern Ontario the first application would be made about May 5, unless the season was unusually late.

Transplanting

One season's tests have shown that if the columbines are dug and set out in a new location during October, or in the spring before the hatching of the eggs, almost perfect control may be obtained. It is not necessary or desirable to remove all the earth from the roots, but the top inch of soil must be knocked away from the crown in order to eliminate the eggs. Fortunately, columbines lend themselves to transplanting unusually well, and if moved in this manner preferably about the first of May, will suffer no ill effects and will bloom quite normally. The simplicity of this method, the speed with which it may be carried out, and the fact that it requires no expenditure for materials, should make it a valuable means of avoiding the borer where only a small number of plants is involved, and in certain cases it might well be practical on a nursery scale. While the procedure has been tested experimentally at Ottawa only once, the results were conclusive; based upon the number of borers established in check and transplanted plots a month after hatching, the percentage improvement over check was 98.5.

The "transplanting" experiment was carried on at Ottawa in the spring of 1939, and the same procedure of quickly building up a heavy infestation of borers by artificial means was followed in this as well as in the larvicidal tests. A plot which contained 144 columbines was used for the purpose, and on October 15, 1938, each of the plants was infested with 25 eggs. The latter were scattered against the foliage and allowed to fall wherever they might; in other words there was no attempt to prevent the eggs from lodging in the center of the crowns. The following spring, the plot was divided into two sections—a "transplanted" plot containing 88 columbines and a check containing 56. On May 4, the columbines in the "transplanted" plot were dug and set out in a location 150 yards distant, while the check plants were not disturbed. As far as possible the earth was left intact around the roots during the transplanting, but the top inch of soil surrounding the crown was removed—a process which added little or nothing to the labour, and in most cases required only two or three sharp blows of the hand.

The columbines in the check and transplanted plots were dissected and examined for larval establishment on June 23-24, and the data recorded have been summarized in Tables II and III. In Table III, the percentage control has been calculated by Abbott's formula, and here again it has been assumed that the potential number of borers established per plant was equivalent to the number of eggs set out.

TABLE II.

PERCENTAGE LARVAL INFESTATION, TRANSPLANTED COLUMBINE EXPERIMENT, OTTAWA, ONTARIO, 1939

Treatment	Total plants observed	Total plants infested	Total borers established	Percentage of plants infested
Transplanted	88	9	9	10.2
Check	56	56	381	100.0

Table III.

Percentage Larval Establishment and Control Transplanted Columbine Experiment, Ottawa, 1939

Treatment	Eggs seeded per plant	Average number of borers per plant	Percentage borers established per plant	Percentage control
Transplanted	25	.1	.4	98.5
Check	25	6.8	27.2	....

In the check plot every plant was infested; the average number of borers per plant was 6.8 and the largest number of borers in any one plant was 16. In the transplanted plot, 9 of the 88 plants were infested, but each of the infested plants contained only one borer. The columbines suffered little or no ill effects from the moving; only temporary wilting resulted and there was no plant mortality. Possibly the transplanted columbines were slightly smaller than the checks at the time of dissection but any difference in the blooms was negligible. As for the distance newly-hatched larvae can crawl in order to reach a columbine, observations made in field and insectary indicate that it is slight—certainly not more than 15 feet and probably considerably less than this. As far as known, the insect can survive on no plants other than columbines.

In a nursery, the factor of labour would appear to prohibit the transplanting of large numbers of *Aquilegia* as a means of escaping the borer; however, in any nursery some moving of plants is necessary from time to time, and it is suggested that such work with columbines be carried on in late April, before the hatching of the eggs.

Literature Cited

Abbott, W. S. 1925, A method of computing the effectiveness of an insecticide. J. Economic Ent. 18: 265-267.

SUCCESSFUL HIBERNATION OF THE EARWIG PARASITE *BIGONICHETA SETIPENNIS* FALL. IN ONTARIO*

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The purpose of this paper is to report the successful wintering of the earwig parasite, *Bigonicheta setipennis* Fall., under outdooe conditions in Ontario. J. H. McLeod, who is now on active military service, was largely responsible for initiating the experiments recorded below, and valuable assistance has been given by members of the Toronto Plant Inspection Office.

This European parasite has been propagated for a number of years on the Pacific Coast, both in the United States and Canada, for release against the European earwig, *Forficula auricularia* Linn., in infested areas in the west. With the discovery of the earwig infestation in Grey county, Ontario, in 1938, arrangements were made at once for a supply of *Bigonicheta* and releases of mature mated adults were made on the infested area. The numbers released totalled 21,472 in 1939 and 18,434 in 1940.

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*Contribution No. 2047, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

To determine the ability of the parasite to hibernate successfully under the more severe conditions which occur in Ontario, several experimental lots of puparia were placed in outdoor locations at Neustadt and Belleville for the winter season of 1939-40. Other lots were held in two of the cold storage rooms at the Dominion Parasite Laboratory, Belleville, to serve as a check. The ten thousand puparia used in these experiments, and all of those yielding adults for liberation, were supplied by the Dominion Entomological Laboratory, Victoria, B.C. Assistance in the propagation work at Victoria during 1939 was given by J. H. McLeod of the Belleville Laboratory. The material arrived in Belleville on October 31, 1939, and was held in storage at 36°F. until November 7 when a portion was removed and prepared for the overwintering experiments. Twenty lots of 250 puparia each were placed out at Neustadt, Grey county, and four lots of 250 puparia each at Belleville in Hastings county. Two lots of 2,000 each, were allowed to remain in storage. Some of the outdoor lots were placed in sheltered locations and others were placed in exposed situations.

Three different types of containers were used for the puparia. In type "A" the puparia were packed in sphagnum moss in small "Edgeworth" tobacco tins with top and bottom perforated. The tins were packed in excelsior in wooden boxes 10 inches by 10 inches by 10 inches. Type "B" container was the usual "earwig trap". This trap consists of two strips of cedar 12 inches by 3 inches by 1 inch, placed together in such a way that one-quarter inch grooves on their faces match to form retreats for the earwigs. The puparia were placed in the grooves, and the ends of the traps were closed with 14 mesh copper screening. In type "C" the puparia were arranged in a single layer in "*Microplectron*" liberation cages, and were thus surrounded by one-half inch of sphagnum moss on all sides.

No adult earwigs were found at Neustadt on November 8 when the material was set out and it was assumed that all were in hibernation quarters at that time. A. Diebel, on whose farm the puparia were placed, recorded the weekly maximum and minimum temperatures for the greater part of the experimental period and also furnished notes on general weather conditions in that area.

Cages set out at Belleville were examined frequently during the spring of 1940. The first sign of *Bigonicheta* emergence was observed on June 14. Three days later the material set out at Neustadt the previous fall was collected and brought to Belleville. Emerged flies, both living and dead, were found in some of the more exposed lots at Neustadt on June 17. It is probable, therefore, that some emerged flies had already escaped, and that the actual emergence from at least three of the lots was greater than the emergence recorded.

The lowest temperature to which the puparia were exposed during the period of the experiment was —20°F. This temperature was reached at both Neustadt and Belleville during the week of January 1. Weekly maximum and minimum temperatures at Neustadt and Belleville during the period November 13, 1939, to June 16, 1940, are given below in Table I.

TABLE I

Weekly maximum and minimum temperatures recorded at Neustadt and Belleville during the period November 13, 1939, to June 16, 1940

	Maximum		*Minimum*	
	Neustadt	Belleville	Neustadt	Belleville
Nov. 13 - 19		50		13
20 - 26		45		14
27 - Dec. 3		49		25
Dec. 4 - 10		49		18
11 - 17	56	42	10	7
18 - 24	56	39	−4	5
25 - 31	38	34	0	−1
Jan. 1 - 7	38	24	−20	−20
8 - 14	40	37	24	−15
15 - 21	26	38	−6	−15
22 - 28	24	27	−4	−3
29 - Feb. 4	36	29	−10	−1
Feb. 5 - 11	36	37	8	−1
11 - 18	34	32	0	3
18 - 25	16	38	0	5
26 - Mar. 3	30	34	10	−2
Mar. 3 - 10	32	37	−2	10
11 - 17	36	35	16	3
18 - 24	32	35	2	2
25 - 31	42	45	20	5
Apr. 1 - 7	40	49	14	22
8 - 14	40	54	18	18
15 - 21	48	56	16	27
22 - 28	58	62	26	27
29 - May 5	54	75	32	30
May 6 - 12		69		32
13 - 19		78		39
20 - 26		81		39
27 - June 2		73		50
June 3 - 9		86		51
10 - 16		82		44

Snow covered the ground at Belleville from the week of December 11 until the mild weather of spring. At Neustadt snow did not arrive until the week of December 18 or one week later than at Belleville.

Data covering the various lots of puparia are presented in Table II.

It will be seen from Table II that greatest survival resulted from storage at 32° and 36°F. Among the lots of puparia overwintered out-of-doors there appears to be no sharp line of demarcation between those wintering in exposed and protected locations. The greatest survival was, nevertheless, quite definitely in the sheltered locations. Puparia placed below the soil surface and those subjected to the extreme conditions of a southern exposure gave poorest survival. These, however, can hardly be considered as normal places of hibernation.

The experiments have clearly demonstrated the ability of *Bigonicheta* to winter successfully in the earwig infested area of Ontario, and especially so in the more sheltered locations where puparia are most likely to be found.

TABLE II

Showing conditions of wintering and emergence of adults from puparia used in the hibernation experiments

Reference No.	Type of Container	Quantity of Puparia	Location and conditions for hibernation	No. Adults Emerged	% Puparia Producing Adults
2	in moss	2000	Belleville, storage at 32°F.	1638	82
1	"	2000	" storage at 36°F.	1601	80
3	C	500	" sheltered with snow coverage	322	64
4	C	500	" covered with leaves, slight snow coverage	315	63
8	C	500	Neustadt, sheltered, dry, partial snow coverage	200*	40
5	B	500	" well exposed, on east side of shed	185*	37
10	C	1000	" covered with leaves, damp, snow coverage	312	31
7	A	500	" well exposed on east side of shed	141	28
9	A	500	" on ground with snow coverage	135	27
12	C	500	" 6 inches below soil surface, western slope	31	6
11	C	500	" 3 inches below soil surface, western slope	26	5
6	C	500	" Severe exposure south side of shed	16*	3
13	B	500	" Near soil surface, snow coverage	records incomplete	

*Emergence already taking place June 17.

THE SYMPHYLID, *SCUTIGERELLA IMMACULATA* (NEWP.), AS A PEST OF GREENHOUSE CROPS IN ONTARIO*

By G. G. Dustan

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There has apparently been nothing previously published on the occurrence of the symphylid *Scutigerella immaculata* (Newp.), known also as the garden symphylid or centipede, in Ontario. According to Michelbacher (4) it was reported in British Columbia by Hyslop in 1927, but the earliest positive record we have for Ontario refers to an infestation in a greenhouse near Grimsby in 1938. A grower at Weston, Ont., reported that it has been causing damage in his greenhouse at least since 1933, and as it is known to be widely distributed in North America, it has probably been present in parts of Ontario for a long time and its damage either overlooked or attributed to other causes. As yet we have no record of it occurring outdoors in Ontario, although it probably does so, and could thus gain entrance to greenhouses with soil and manure.

Description—The adult symphylid is a delicate slender animal about one-quarter inch long, with 12 pairs of legs and biting mouth parts. They are not able to make their own tunnels but move actively in soil crevices and hastily seek shelter when disturbed. The eggs, which are white and have a distinct net-work of raised ridge-like processes, are laid in clusters of 3 to 15 in soil crevices. Newly hatched larvae have 6 pairs of legs and add another pair after each moult, 6 moults bringing them to maturity. Moulting may continue at irregular intervals throughout adult life, which may extend over a period of 4 years or longer. Several individuals which we started to rear 7 months ago are still living.

According to Compton (1) reproduction is at a low ebb in greenhouses during December and January and increases during later winter and spring to the maximum rate in the summer. Eggs hatch in 8 to 21 days, and maturity may be reached in 40 days, although under average greenhouse conditions, it is said to take from 3 to 6 months.

Injury—Different types of injury are illustrated in the accompanying photographs. The two main types are (a) the total destruction of the smaller roots as shown by the shepherd's purse, and (b) boring of small shallow holes in the larger roots and portion of the stem below the ground. Disease organisms may gain entrance through these holes and cause secondary injury. In the heaviest infestation which we have seen, over 85 per cent of the plants in a bed of ranunculus were killed and the remainder stunted. Some of the surviving plants had from 20 to 30 symphylids each around their roots, while in the same bed, 44 were found about the roots of a plant of shepherd's purse. A bed of snapdragon was found to be injured and failing to make good growth, although symphylids were not abundant at the time of examination. On several of the plants picked at random the number of holes per stem varied from 23 to 58.

The most serious losses from symphylids result from injury to plants newly set out. If many symphylids are present at this time the plants may be seriously set back or killed outright, whereas if they can once become well established some plants can apparently withstand a considerable amount of feeding.

So far we have recorded symphylid injury on chrysanthemum, statice, ranunculus, feverfew, sweet pea, buddleia, Easter lily, snapdragon, tomato, and aster, and it is known to attack many other plants.

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Distribution in the soil—Michelbacher (5) claims that outdoors *S. immaculata* (Newp.) is not restricted to any particular soil level but may be found from the surface to a depth of 4 feet or more, with moisture being the most important factor determiniмg its vertical distribution, other factors being temperature, soil texture and structure, and vegetation. Filinger (2) makes the statement that the garden symphylid has a peculiar habit of migrating to the subsoil under greenhouse conditions with the approach of warm weather in the spring. Vertical distribution is an important consideration in connection with control measures because few individuals would be killed below about 18 inches by sterilization with steam or chemicals as ordinarily used.

We carried out an experiment in 1940 to determine the effect of drying the soil on the size and distribution of the symphylid population in raised benches and ground beds. Each of the two ground beds consisted of three 12 inch unglazed tiles, cemented together end to end, and placed vertically in the soil. These were filled with 18 inches of well packed subsoil, 9 inches of cinders for drainage, and 9 inches of top-soil from an infested source, containing approximately the same number of symphylids for each bed. The raised beds consisted of two sections of bench, 1 foot square, enclosed with 5 inch boards and filled with some of the same infested soil.

These beds were set up on June 9, and lettuce, tomatoes, and radishes grown in each with normal watering until August 1, after which one ground bed and one raised bench were left unwatered until September 3, when the soil was lifted in 1 or 2 inch layers from each bed and carefully examined by hand, the number and stage of development of the symphylids present being noted.

The results of these examinations are given in the following tables.

TABLE NO. 1 *Vertical Distribution of Symphylids in Greenhouse Ground Beds*

Distance from surface. Inches	Nature of soil	Total Number		Population per cubic foot		Percentage Distribution	
		Wet Bed	Dry Bed	Wet Bed	Dry Bed	Wet Bed	Dry Bed
0- 2	Top-soil	0	0	0	0	0.0	0.0
2- 4	"	5	1	38	7	0.7	0.5
4- 6	"	102	11	777	84	13.5	5.8
6- 8	"	164	25	1249	190	21.8	13.1
8- 9*	"	200	58	3040	882	42.7	60.7
9-11	Cinders	17	9	129	68	2.5	4.7
11-13	"	5	6	38	46	0.7	3.2
13-15	"	8	4	61	30	1.1	2.1
15-17	Subsoil	85	19	646	144	11.3	9.9
17-19	"	44	0	334	0	5.8	0.0
19-21	"	4	0	30	0	0.5	0.0
21-36	"	0	0	0	0	0.0	0.0
Total		634	133				

*1 inch layer

TABLE NO. 2 *Vertical Distribution of Symphylids in Raised Benches*

Distance from surface Inches	Total Number		Population per cubic foot		Percentage Distribution	
	Wet Bed	Dry Bed	Wet Bed	Dry Bed	Wet Bed	Dry Bed
0 - 1	2	0	24	0	1.2	0.0
1 - 2	6	6	72	72	3.5	2.1
2 - 3	2	0	24	0	1.2	0.0
3 - 4	7	5	84	60	4.1	1.7
4 - 5	152	289	1824	3336	90.0	96.2
Total	169	300				

TABLE NO. 3 *Summary of Vertical Distribution of Symphylids in Ground Beds*

	Moist Bed		Dry Bed	
Soil Layer	No.	Percent	No.	Percent
Top-soil	471	74.2	95	70.4
Cinders	30	4.7	19	14.3
Subsoil	133	21.1	19	14.3

TABLE NO. 4 *Summary of Stage of Development of Symphylids in Different Soil Layers in Ground Beds*

	Top soil		Cinders		Subsoil	
Bed and Stage	No.	%	No.	%	No.	%
Moist ground bed						
Unhatched eggs	149	92.5	0	0.0	12	7.5
Larvae —						
small	156	95.1	2	1.2	6	3.7
medium	232	80.7	19	6.7	36	12.6
Adults	83	45.3	9	4.9	91	49.8
Dry ground bed						
Unhatched eggs	0	0.0	0	0.0	0	0.0
Larvae —						
small	16	84.2	1	5.3	2	10.5
medium	24	58.5	7	17.1	10	24.4
Adults	55	75.2	11	15.1	7	9.7

TABLE NO. 5 *Further Summary of Stage of Development of Symphylids in Ground and Raised Beds*

	Moist Bed		Dry Bed	
Stage of Development	No.	Percent	No.	Percent
Ground Beds				
Eggs	149		0	
Small larvae	156	33.8	16	16.8
Medium larvae	232	50.3	24	25.3
Adults	83	15.9	55	57.9
Raised Beds				
Eggs	55		0	
Small larvae	91	53.9	75	26.9
Medium larvae	64	37.8	158	54.6
Adults	14	8.3	56	19.6

The classification of the active forms as listed in Tables 4 and 5 is based on an examination by the unaided eye in which an attempt was made to put symphylids of the first 3 instars in the "small" class, those in the fourth and fifth instars in the "medium" class, and the remainder in the "adult" class. It should be noted that in Tables 4 and 5, the eggs have not been included in the percentage composition of the population.

The data in the above tables bring out the following points of interest: (1) Contrary to expectation there was little difference in vertical distribution between

the moist and dry ground beds. As a matter of fact symphylids were found deeper in the moist bed than in the dry, possibly because of the greater number in the former. (2) The maximum concentration in both ground beds was in the inch of soil just above the cinders, and in the raised beds in the lower inch of soil. (3) No symphylids were founder deeper than 6 inches below the subsoil surface, i.e. 21 inches below the surface of the top-soil. If the subsoil had been of a more open type, it is quite likely they would have been found deeper. (4) In the moist ground bed approximately 95 per cent of the small larvae, 80 per cent of the medium larvae and 45 per cent of the adults were in the top-soil, showing as would be expected that the larger forms wandered farthest, while the smaller ones remained nearer the source of food. Over 90 per cent of the eggs were also found in the top soil indicating that most of the breeding took place there. (5) Breeding apparently stopped completely in the dry beds, because no unhatched eggs were found, and the proportion of the population in the adult stage was greater than in the moist beds. (See table). No explanation can be given for the fact that a larger number of symphylids were found in the dry raised bed than the moist, although possibly a larger number were added at the start, despite the fact that an attempt was made to keep the numbers equal. (6) This symphylid can apparently withstand quite dry soil conditions for a considerable length of time, because the moisture content of two samples from the raised dry bed was 6.2 per cent and 9.2 per cent respectively, which is below the wilting point for most plants in soil of this type.

This experiment is being repeated when a considerably longer drying period will be given.

Control experiments—At the present time the only practical method known of controlling symphylids in greenhouses is to replace ground beds with raised benches filled with sterilized soil or soil known to be free of symphylids. Symphylids will not come up from below to re-infest soil in the benches. However, as raised benches are not satisfactory for some crops and entail a large expense, other methods must be attempted.

Various methods of sterilizing the soil with steam and chemicals have been tried by other workers with varying degrees of success, none of them being entirely satisfactory under all conditions owing to the difficulty of killing those deep in the soil.

Some success has been reported (4) from the use of a weak emulsion of carbon disulphide applied to the soil while plants are present, and recently Hamilton (3) has succeeded in reducing the number of soil insects by using a weak emulsion of dichlorethyl ether. The latter appears to be considerably less toxic to the plants than carbon disulphide. In the following discussion dichlorethyl ether is referred to as D.E., and carbon disulphide as CS_2.

Preliminary tests—The following materials were tested on Easter lilies in 6 inch pots which became infested with symphylids after resting for a month or more on an infested ground bed.

(a) Dichlorethyl ether emulsion at the rate of 4cc. D.E. per square foot. The stock emulsion was made as follows using two emulsifiers:

1.	D.E.	66 cc.
	Fish oil soap	3 cc.
	Water	66 cc.
2.	D.E.	66 cc.
	Sodium lauryl sulphate	1 gm.
	Water	33 cc.

Both formulae gave good emulsions when shaken vigorously, although the sulphate emulsion broke much more rapidly. For use the stocks were diluted with water to a strength of 1.44% and 2.02 oz. applied to each 6 inch pot, giving a rate of application of 4 cc. D.E. per square foot.

(b) 4.04 oz. of 0.72% D.E. emulsion (soap as emulsifier) for each pot. This gives the same amount of D.E. as in (a) but with twice the amount of water to give a heavier soaking.

(c) 66% carbon disulphide emulsion diluted 1-300, of which 3.3 oz. per pot were used, giving a rate of 4.3 cc. CS_2 per square foot. The stock emulsion was made with fish oil soap in the same manner as the D.E. emulsion.

(d) 4 oz. of nicotine sulphate 1-200 poured over the soil of each pot.

(e) Corrosive sublimate 1-1600, applied at the rate of 4 oz. per pot. The soil temperature was 60°F. when these materials were applied. Examinations were made one week later with the following results:

Treatment		*Symphylids* No. living	*Symphylids* No. dead	% *Mortality*
(a1)	D.E. — soap (first test)	7	29	80.5
(a2)	D.E. — soap (second test)	0	46	100.0
(a3)	D.E. — sodium lauryl sulphate	9	63	87.5
(b)	D.E. — soap	0	21	100.0
(c)	Carbon disulphide	1	27	96.5
(d)	Nicotine sulphate	5	8	61.5
(e)	Corrosive sublimate	9	4	30.8
(f)	Check	67	1	1.5

A second test of D.E. emulsion at rates of 4 cc. and 6 cc. per square foot resulted in 100 per cent mortality at both concentrations, the total number of symphylids counted being 181.

Tests under greenhouse conditions—Both carbon disulphide and dichlorethyl ether have been given tests under commercial growing conditions, but as yet we have little exact information on their effectiveness combined with safety to the plants.

In one test two small sections of bed containing feverfew and statice were treated with carbon disulphide emulsion at the rate of 4.3 cc. CS_2 per square foot, *i.e.*, a 66 per cent emulsion diluted 1-300 and added at the rate of 4 gallons per square yard. Four days later a count around one plant revealed 23 dead and 9 living, giving a kill of 71.9 per cent as compared to 3.8 per cent mortality in the check. No injury from CS_2 was noted.

A few days later, on February 23, a larger test was made on the same bed with the same materials and in addition a few flats of clarkia seedlings were treated. The soil temperature ranged from 57° to 64°F. No injury resulted to the statice or feverfew, although the clarkia seedlings were badly stunted. No symphylid counts were made but the treated plants appeared to make somewhat better growth than the checks.

On July 18, we had an opportunity to test D.E. emulsion on chrysanthemums which had been set out in a greenhouse ground bed on June 25, and which were showing injury from symphylids. Five plots, each 17 by 4½ feet, were treated with the dilute emulsion as described for lily pots, using a watering can with a partially plugged spout to apply the material. The soil temperature at 2½ inches was 65°F.

On August 9, the grower was so pleased with the results of this treatment that he proceeded to treat all remaining sections of his beds which showed injury, except for a small check, although we told him it was probably too late to get much benefit. Our observations at this time showed that whereas the plants in the check plots were not making vigorous growth, were uneven in size, and had dull looking foliage, those in the treated plots were much evener in size and the foliage had a noticeably healthier sheen.

As the grower did not wish to lose many plants we were not able to make an extensive count of symphylids. One check plant had 5 symphylids around the roots and two treated plants had one each. At the time of writing (October 31) the treated chrysanthemums appear to be somewhat better than the check in height and evenness of growth. It is quite likely that more benefit would have been obtained by treating sooner after the plants were set out.

There was no apparent injury from dichlorethyl except on one variety, Seidwitz, which was badly infected with *Verticillium* fungus. Approximately 9 per cent of the plants of this variety were dying on August 9. It would appear that healthy chrysanthemums can withstand this treatment, while those in a badly weakened condition may suffer some injury.

The use of steam and chemicals in treating beds.—In an attempt to eradicate symphylids from a greenhouse ground bed the following treatments were applied to large sections of a heavily infested bed on February 12, 1940:

(a) Carbon disulphide was injected into the soil, using 1½ oz. for each 6 inch hole, spaced 18 inches apart in rows 13 inches apart. One half the treated area was covered with a tarpaulin and the other half watered sufficiently to wet the soil to a depth of one inch.

(b) The same treatment was given to the layer of cinders on another section of bed after the top-soil was removed. The top-soil was sterilized elsewhere by steam and later returned to the bed.

(c) The soil was sterilized with steam at 10 pounds pressure for 1½ hours, using 6 tile lines 11 inches apart, laid on top of the cinders 6 inches below the soil surface. A temperature of 210°F. was attained at a depth of 6 inches and potatoes at 1, 3 and 6 inches were well cooked by this treatment.

All these treatments gave an apparently high degree of control. Very few beans, sown about two weeks after treatment, were destroyed by symphylids in the treated plots, whereas only 28 per cent survived in the checks. However, an examination of the soil showed that a few symphylids survived the CS_2 treatment in the section of bed not covered with the tarpaulin to retain the gas. This happened even in the cinder treatment. No symphylids were found in the top foot of soil treated with steam, but very likely a few survived below this level. It is possible that those found living after the treatments came from the adjoining walks or had been protected in the old tiles which were in the wall of the bed.

We have further evidence that steam sterilization is not effective in all cases. A grower in St. Catharines took great pains to sterilize carefully his ground beds in June. We checked this work and were satisfied a good job was done, but by July 15 symphylids were present again in destructive numbers. Undoubtedly many must have survived below the level reached by the steam.

It is claimed that a much better kill is produced if, after a crop is taken off, the soil is kept moist up to the time of sterilization, as this will tend to keep the symphylids from going down in search of moisture. However, our findings mentioned earlier indicate that this downward movement is slow at least under the conditions of our experiment.

Further control experiments are being planned in an attempt to improve the results from steam sterilization and to investigate other chemical methods.

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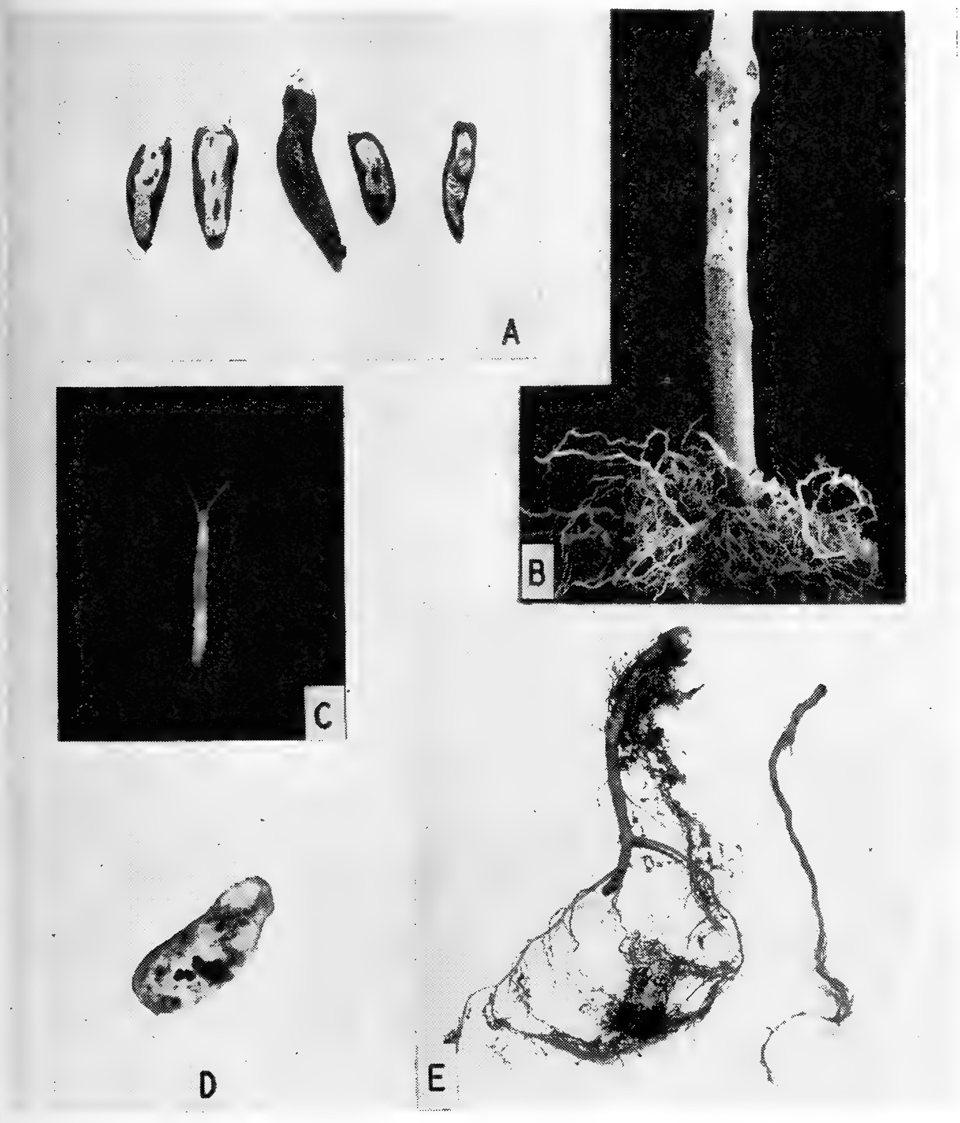

Different types of symphylid injury. A. On ranunculus roots. All except centre root have been cut open to show feeding tunnels within. B. Snapdragon. Note feeding holes on portion of stem which was below soil surface. C. An adult symphylid, X4. D. Injury to bean cotyledon. E. Shepherd's purse roots, the one on right injured by symphylids. Note scars on root as well as lack of rootlets.

BIOLOGICAL CONTROL OF THE CODLING MOTH IN ONTARIO*

By H. R. Boyce

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Introduction

The control of the codling moth, *Carpocapsa pomonella* L. in Ontario apple orchards, particularly in the warmer sections of the province, has become a more serious problem of late years. The pest appears to show a considerable tolerance toward the poisonous sprays used, and growers must apply from 5 to 8 sprays to secure reasonably clean fruit. This involves a considerable reduction in the growers profits, and possibly in time a poisoning of the orchard soils.

Since June, 1937, an effort has been made to determine the extent to which the codling moth was subject to attack by biological agents, such as parasites, predators and diseases. The observations were to serve also for the accumulation of information which would form a basis for evaluating conditions when foreign parasites became available for liberation.

The greater part of the information concerning the natural control of the codling moth presented here is based on records obtained in orchards of the Niagara district, and mainly from two commercial orchards in the vicinity of Beamsville, Ont., in addition to a well cared for orchard located on the Horticultural Experiment Station at Vineland Station, Ont. The latter orchard has received no codling moth sprays since 1931, but has been sprayed with the fungicides. The Beamsville orchards have received codling moth sprays and fungicidal sprays to a varying degree each season but these were not usually thoroughly applied.

Egg Parasitism

Records of the parasitism of codling moth eggs by *Trichogramma embryophagus* (Hartig) were obtained in the H.E.S. No. 2 and Creelman orchards during the years 1938 and 1939. In 1938, parasitism in the Creelman orchard was 2 per cent on August 8, and 52.2 per cent on August 29. In the same season a parasitism of 14 per cent was recorded on August 23 in H.E.S. No. 2. During August, 1939, 4 to 11 per cent of the eggs were parasitized in the Creelman orchard, and 5 to 7 per cent in the H.E.S. No. 2 orchard. The figures secured merely indicate the presence of this parasite, as it was impracticable to make a detailed study of its abundance due to the difficulty in locating adequate numbers of codling moth eggs.

Larval Parasitism

Records of larval parasitism were obtained in the various orchards by trapping the mature larvae to facilitate the making of collections. Bands of 3-ply burlap, made commonly from ordinary grain bags, were most generally used. These were placed either one per apple trunk about 6 inches from the ground, or one per trunk with additional bands on the main scaffold branches above the crotch. When the latter method was used two inch bands of tree tanglefoot were placed above the truck bands, and immediately below those on the branches. The chief disadvantage of this band was the mortality caused when they were removed, as the cocoons were torn open and the larvae had to be transferred to corrugated paper strips where both parasitized larvae and unparasitized were forced to spin a second cocoon. Tearing open of the cocoons at the time of collection would generally cause any external parasites to be either lost or injured.

*Contribution No. 2048, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Paper bands were first used during the 1940 season, and consisted of a two inch wide strip of coarse, corrugated straw board, covered with a strip of special black building paper which was free from tar. These bands require longer to prepare and to apply. In addition, a further problem was encountered with these, as woodpeckers readily found the larvae concentrated in them and removed very large numbers. Woodpeckers attack the larvae in burlap bands occasionally but not seriously.

The most abundant larval parasite during the years 1937 to 1940 inclusive, was *Ascogaster quadridentatus* Wesm., (*A. carpocapsae* Vier.). Larvae containing this parasite were readily detected by their reduced size and, as a consequence, parasitism by this form may be determined without rearing the host. Parasitism by *Ascogaster* varied condiserably from orchard to orchard and within an orchard in succeeding seasons. Parasitism in the three main observation orchards is shown as percentages, in the table following:

Year	*H.E.S. No. 2 Vineland Station*	*Stouck Beamsville*	*Creelman Beamsville*
1937	24.6	22.0	20.4
1938	21.2	7.0	21.8
1939	9.1	7.8	15.6
1940	8.5	1.7	5.9

The parasitism as shown for these orchards was, in general, quite typical for the Niagara district. An exception was a young, unsprayed orchard at Homer, which had a parasitism of 43.6 per cent in 1938.

Several other species of parasites were reared occasionally from codling moth larvae. These were not sufficiently abundant to cause a measurable reduction of the larval population, hence it will be sufficient to mention the species following: *Dibrachys cavus* (Wlk.), *Macrocentrus delicatus* Cress., *Macrocentrus instabilis* Mues., *Macrocentrus ancylivorus* Roh. and *Phanerotoma* sp.

Pupal Parasitism

Codling moth pupae were singularly free from parasitism. On several occasions *Dibrachys cavus* (Wlk.) was reared as an external parasite of prepupae, and as an internal parasite of pupae. Single specimens of *Eupelmus cyaniceps* Ashm. and *Eurytoma* sp. were reared from pupae in 1938. During 1940 three specimens of *Pimpla inflata* Townes emerged from codling moth pupae.

Hyperparasitism

The effectiveness of *Ascogaster* was restricted each season by the attack of a number of species of *Perilampus*. These chalcids are particularly interesting forms, as the first stage larvae are free-living, motile and possess a highly sclerotized and spiny exterior. It is supposed that they hatch from eggs laid on the apple foliage or fruit, as such oviposition habits are recorded as common for the genus. These planidia bore their way into both unparasitized and parasitized codling moth larvae, but do not develop any further in the former. In larvae containing those of *Ascogaster* the *Perilampus* winters over in fat bodies of the primary host. When development of *Ascogaster* larvae is resumed in the spring the planidia enter them, and remain there until the former have completed larval development, spun their cocoons and pupated. The planidia then emerge from the pupae and commence to feed externally. The plandial stage is followed by three typical chalcid larval instars, and pupation takes place within the *Ascogaster* cocoon, from which the adult *Perilampus* emerges by chewing a ragged hole with its powerful mandibles.

Two species of *Perilampus* have been determined from codling moth material, these being *P. fulvicornis* Ashm. and *P. tristis* Mayr. At least one and possibly several other species are at present undetermined. The actual abundance of *Perilampus*, as determined from emergence during the 1937-38-39 seasons, for three orchards, is recorded as per cent of *Ascogaster* parasitized in the following table.

Year	*H.E.S. No. 2 Vineland Station*	*Stouck Beamsville*	*Creelman Beamsville*
1937	48.5%	55.4%	71.7%
1938	51.5	23.2	50.6
1939	42.4	16.6	48.2

Codling moth larvae parasitized by *Ascogaster* were occasionally attacked by the chalcid *Dibrachys cavus* (Wlk.).

Larval Predators

Predatism on codling moth larvae by arthropoda was generally of little consequence. Predacious insects were most frequent and those observed belonged to the orders Coleoptera, Hemiptera and Hymenoptera. The forms that were actually observed feeding on codling moth larvae are listed below.

Coleoptera Family Trogositidae—*Tenebroides corticalis* Melsl.
Hemiptera " Reduviidae—*Acholla multispinosa* DeGeer
" Nabidae—*Pagasa fusca* (Stein)
Hymenoptera " Formicidae—*Solenopsis molesta* Say

Of those listed, the most important was *Tenebroides*, which was particularly abundant each season in the Stouck orchard at Beamsville.

The thief ant, *Solenopsis molesta* Say was observed in numbers on an occasional banded tree near which the nest happened to be located. In such cases a number of codling moth larvae and pupae were attacked in their cocoons.

Many species of arachnids were present in all orchards each season. Doubtless many of these fed on codling moth larvae when they became entangled in the webs while wandering about the trees. The only species that was actually observed feeding on larvae was *Aegelena naevia* Walck. Destruction of larvae by this species was fairly common.

Two, as yet unidentified, species of centipedes were taken in 1940, while feeding on larvae. These centipedes were present in all orchards in small numbers.

The most effective predators attacking larvae were woodpeckers. Predatism by these occurred in the orchards under observation each year. An attempt was made to evaluate their effect on the populations of overwintering larvae, by periodical visits to selected orchards to determine their abundance, and by recording the numbers of larvae removed from sample trees. In general, observations were made at weekly intervals in the four orchards selected, from November 1937 to May 1938, and from late September 1938 to May 1939. Very few birds were seen, 4 downy woodpeckers, *Dryobates pubescens medianus* Swainson, 4 hairy woodpeckers, *Dryobates villosus* Linn., in 1937-38; and 5 downy and 3 hairy woodpeckers in 1938-39. Such data are not particularly conclusive as to the actual abundance of these birds.

Predatism on individual trees was studied on three trees in the H.E.S. No. 2 orchard at Vineland Station in 1937-38. In late October these were examined

carefully, from the main scaffold branches to the ground level. Punctures made in the bark by woodpeckers were opened to learn if a fresh cocoon had been destroyed, and then marked with a coloured pencil to prevent confusion during later examinations. Observations were made at intervals until cages were placed about the trunks in May, shortly before moth emergence. The procedure was essentially the same in 1938-39, except that two trees were selected in the H.E.S. No. 2 orchard and two in the Creelman orchard at Beamsville. The combined numbers of larvae destroyed, codling moth adults and parasites emerging were considered as representing the total larval population on the portions of the trees examined. On this basis, the percentages of larvae destroyed by the birds are shown in the following table:

Season	*Locality*	*Number of larvae destroyed*	*Number of moths and parasites*	*% of larvae destroyed*
1937-38	H.E.S. No. 2	135	66	67.1
1938-39	H.E.S. No. 2	126	7	94.7
1938-39	Creelman	40	10	80.0

The sample trees had sound healthy bark so the maximum of larvae would be expected to be removed. Examination of trees having thick areas of dead bark or deep wounds indicated that, although woodpecker attack was well defined by the areas chiselled out, many larvae were located too deeply and as a consequence escaped destruction.

A number of codling moth adults emerged in the cages which did not come from the trunks, but from bark fragments on the soil, mummied apples and clods of soil. These were not included in the records as larvae in such situations would be likely to escape attack. Examinations of the smaller branches of the trees revealed the presence of a number of larvae, but no evidence was secured that woodpeckers removed larvae from such branches.

Diseases

During the period covered by the investigations a few codling moth larvae were found, in the bands, which had been attacked by entomophagous fungi. There appeared to be several of these present though none have been identified. A few specimens were destroyed also by an unidentified virus or bacterial disease. These diseases were usually of little significance, but during 1940 the virus or bacterial disease was more prevalent in several orchards. Records of the number of larvae killed were obtained for the H.E.S. No. 2 orchard this year, and show a mortality of 15 to 16 per cent of the total larvae trapped in bands.

General Status of Natural Control Factors

A considerable variety of parasites, predators and diseases have been found attacking the codling moth in the Niagara district, in varying intensities during the years 1937 to 1940, inclusive. None, however, were present in sufficient numbers to produce economic control of the pest in the sprayed or unsprayed orchards investigated.

Parasite Liberations

Initial releases of the spin-up parasite, *Ephialtes caudata* Ratz., were made in the Niagara area during 1940. This parasite was secured from France through investigations carried on by the Farnham House Laboratory. The material liberated was propagated at the Dominion Parasite Laboratory, Belleville, Ontario.

On August 15, 20, on September 5, 60 and September 26, 80 mated females of this species were released in a heavily infested, unsprayed section of an orchard

on the Experimental Farm, Vineland Station. On October 1, 100, and October 12, 150 mated females were placed in the Larkin orchards at Queenston.

A cursory examination of several trees in the Experimental Farm orchard. early in October, revealed the presence of two larvae parasitized by *Ephialtes*, If this parasite is able to survive our winters it should have an excellent opportunity to become established in the district.

Acknowledgments

The investigations were conducted under the direction of A. B. Baird, in charge of the Dominion Parasite Laboratory, Belleville, Ont. The initial observations of 1937 were obtained by W. E. van Steenburgh. The writer is indebted to W. Putman, Dominion Entomological Laboratory, Vineland Station for the 1937-38 records on woodpecker predatism, and to J. Marshall, Dominion Entomological Laboratory, Vernon, B.C., for suggesting the paper bands. Timely suggestions and assistance were also received from W. A. Ross and staff of the Dominion Entomological Laboratory, Vineland Station, Ont.

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THE INTRODUCTION OF TWO EUROPEAN PARASITES OF THE CODLING MOTH, *CARPOCAPSA POMONELLA* L., INTO CANADA*

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The codling moth, *Carpocapsa pomonella* L., is probably the most expensive insect on the North American continent if judged by the annual expenditure on materials, labour, and research in attempting to control it, together with the annual losses actually occasioned by it. The pest was introduced from Europe many years ago and has become increasingly serious in Canada each year, particularly during the last decade. Failure to obtain economic control by the use of poisons and lack of attack by native parasitic insects led to arrangements being made by the Dominion Entomologist, for a thorough investigation of codling moth control in Europe with the primary object of securing insect parasites for colonization in Canada.

This investigation was incepted in the spring of 1939 by F. J. Simmonds, working in France under the immediate direction of Dr. W. R. Thompson, Superintendent of Farnham House Laboratory, It was, unfortunately, interrupted by war developments known to all and Mr. Simmonds was forced to return to England on the last boat leaving Bordeaux in June, 1940. The work done showed the codling moth as being attacked by a great variety of parasites but owing to the abrupt manner in which Mr. Simmonds' work in France was brought to a close, only a small amount of the material he had collected was saved, and his car, equipment and experimental notes all had to be left behind in Bordeaux. A small consignment of material had been despatched to Farnham House early in May and this, packed in two small cigarette tins, finally reached Belleville, June 11, 1940.

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Although most of the parasites had emerged or died in transit, the remaining cocoons were placed in incubation and between June 11 and July 5 there emerged twenty adult parasites of two species, viz.—

4 male and 6 female *Ephialtes caudata* Ratz.
9 male and 1 female *Cryptus sexannulatus* Grav.

These adults as they emerged were placed in Melrose boxes according to species and sex, with loaf sugar and raisins provided for food, and dampened dental roll for moisture. Both species under natural conditions attack the spin-up or cocoon stage of the host.

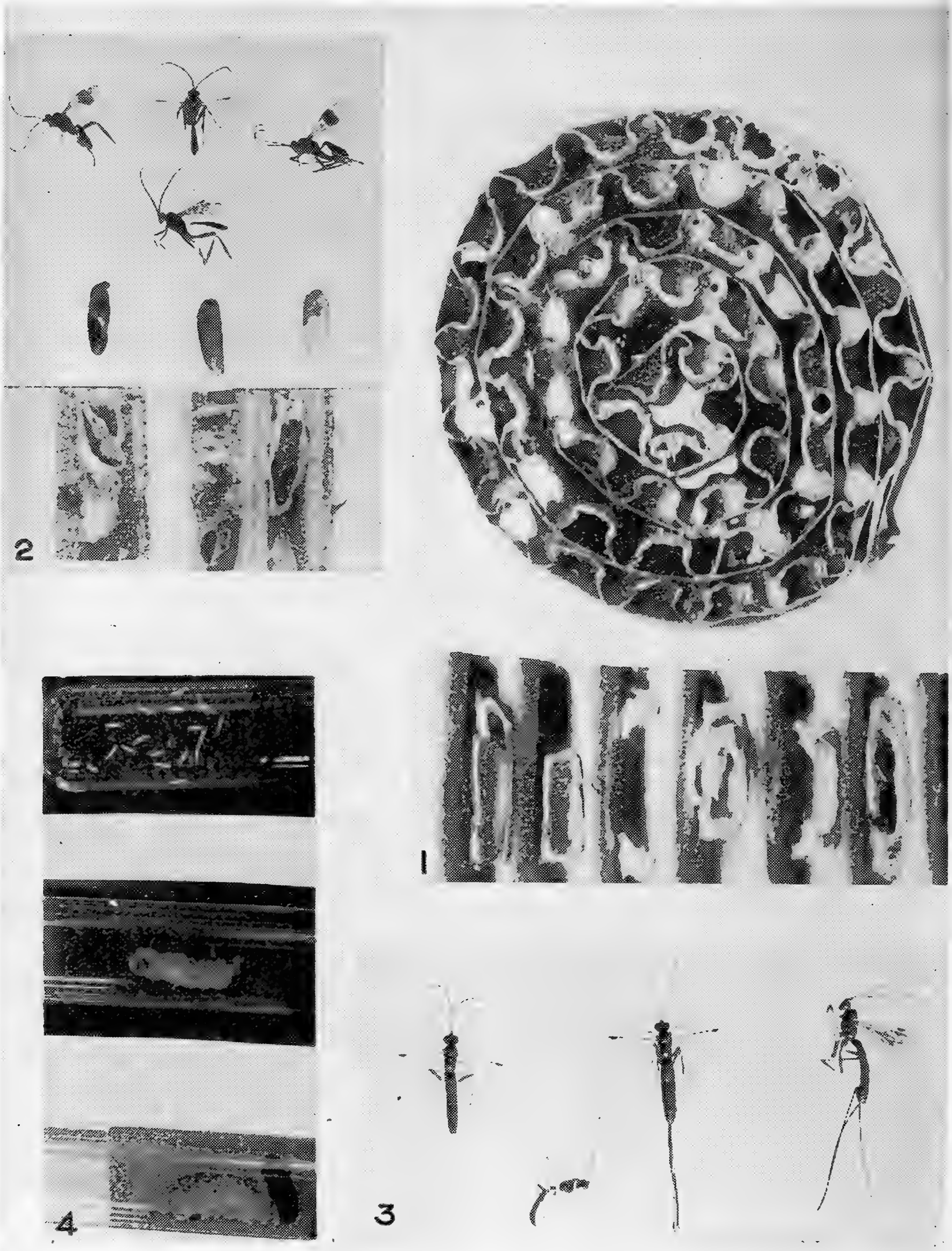
Propagation of Cryptus sexannulatus.

The solitary female emergent mated readily on the second day after emergence in a large cotton cage in which she was subsequently kept. No further mating took place and it may be noted here that *Crypius* females obtained in the succeeding generations also refused males after the first mating. Codling moth larvae and pupae were supplied daily for oviposition, these being varied as to age and type of spin-up. Different conditions were provided from time to time including a variation of lighting from direct sunlight and electric lamps to semi-darkness, and at temperatures of 70°F. and 80°F., with relative humidity of approximately fifty per cent. On July 5, eight days after emergence, interest was shown towards corrugated cardboard strips containing spin-ups pinned to the top of the cage, and to spin-ups on apple bark placed on the bottom of the cage From then on host spin-ups were left in the cage. No oviposition was actually. observed till July 11, when three eggs were found on one larva in a cocoon on apple bark. The eggs obtained were reared on codling moth larvae paralyzed by the hot water method. The next day three eggs were found and treated similarly. At this point, it was noticeable that an older spin-up with a heavy cocoon was preferred by the *Cryptus* female. Various methods to thicken the cocoon were tried, such as placing sawdust and blotting paper in vails containing spinning larvae. These were not as successful as the corrugated paper strips so the latter simpler method was adopted and followed throughout.

The strips of corrugated paper containing spin-ups were cut into small pieces and distributed around the floor of the cage. After sufficient oviposition the strips were removed and placed for development and emergence in labelled jars with covers of cotton gauze held by rubber bands. The temperature was kept at 70°F. and the room humidity of fifty per cent was raised in the jars by dampening the gauze jar tops with distilled water every other day. Emergence of adults from the F1 generation consisted of four males, five females; the F2 generation forty-nine males, seven females; and the F3 generation ten males and three females. A large part of the larvae in the F2 and F3 generations went into diapause and are now in storage. At 70°F. a preoviposition period for females of about six days from emergence is to be expected, and a period from oviposition to emergence of about twenty-two to twenty-three days. Development of this parasite took place satisfactorily on both mature larvae and pupae.

Propagation of Ephialtes caudata:

Ephialtes females mated very readily, mating often taking place between freshly emerged males and females. After mating, the males and females were separated and host spin-ups in corrugated strips were introduced into the oviposition cage, this being a cotton gauze cage with celluloid slide front. During the preoviposition period especially, many host larvae are destroyed due to the feeding on body juices by the female, some males also have been noticed to feed on these juices. When larvae were scarce it was, therefore, found a saving to



Explanation of Figures

1. Codling moth spin-ups in corrugated strips, as used in cages.
2. *Cryptus sexannulatus* Grav. Males and females; parasite cocoons removed from spin-ups with one host pupal case attached; and spin-ups showing remains of host larvae and pupae.
3. *Ephialtes caudata* Ratz. Males and females.
4. *Ephialtes caudata* Ratz. Eggs; young larvae feeding on host; and at bottom, mature larva in cocoon beside host remains.

introduce decapitated larvae into the cage first, for feeding purposes, so later the host material could be introduced without much loss from feeding. Sugar and raisin and a dampened dental roll were placed in all cages with the adults. Different types of spin-ups were presented successfully for oviposition. These included fresh spin-ups from field collected larvae both going through to emergence and going into diapause,and overwintering spin-ups soaked for contact moisture and presented almost immediately. It was also observed that *Ephialtes* will lay eggs on young pupae. The resulting larvae noticed died after trying to feed on the pupae at the intersegmental joints and it is doubtful if emergence ever occurs from such ovipositions.

The original four males and six females gave rise to an F1 generation of eighty-six males and eighty-five females, and an F2 generation of four hundred and seventy-six males and four hundred and sixty-three females. The last of the F2 and F3 generation and all of the F4 generation went into diapause. A sufficient surplus of adults accumulated from the F2 and F3 generations to allow for the liberation of experimental colonies in the Niagara District, Ont. During a period covering August 14 to October 11, four hundred and ten mated females were shipped to H. R. Boyce at Vineland Station, Ont. One hundred and sixty females were liberated at the Experimental Farm, Vineland Station, and two hundred and fifty females at the Larkin Farm, Queenston, Ont.

Early in October Mr. Boyce reported that he had collected two codling moth spin-ups containing an *Ephialtes* egg and an *Ephialtes* larva respectively, thus furnishing definite evidence that this parasite will work in the field in Ontario, and we hope a good establishment may be recorded at an early date.

PRELIMINARY EXPERIMENTS ON THE CONTROL OF THE CRANBERRY FRUIT WORM IN NEW BRUNSWICK*

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The cranberry fruitworm *Mineola vaccinii* Riley is a serious pest of the bog cranberry along the northern and eastern coasts of New Brunswick. Further inland and in the central parts of the province the insect is not so prevalent. Cranberry growers in the coastal areas are not compelled to provide facilities for the flooding of their bogs, as their crops are usually harvested before damaging frosts occur, and as many of the bogs are located where flooding would be difficult or impossible this practice cannot be used for the control of the fruit worm. In 1939 and 1940, various insecticides, including those recommended for the control of this insect elsewhere, were compared in a small heavily infested bog located at St. Charles, Kent County. This bog is located on almost level highland soil surrounded by cultivated fields and is 60 feet wide and approximately 260 feet long. It is seven years old with a good stand of vines practically free of weeds.

In 1939, it was decided to compare four of the most promising insecticides on this bog which was quartered into areas approximately 60 feet square with a small area left untreated at one end to serve as a check. The plots ran in sequence as follows: plot (1) check; plot (2) nicotine sulphate spray, one quart to 75 gallons of water; plot (3) two per cent *rotenone-gypsum dust; plot (4) two per cent *rotenone spray; and plot (5) 50 per cent synthetic cryolite-gypsum dust. The

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*Derris powder of 4 per cent rotenone content.

sprays contained three pounds of lignin pitch per 100 gallons and the dusts three per cent. The sprays were applied at the rate of 400 gallons per acre and the dusts at an approximate rate of 60 lb. per acre.

The spraying apparatus consisted of a heavy type of hand-pumped outfit equipped with 50 feet of high pressure hose carrying a four-nozzle broom spray rod using an "angle". The plots were sprayed in strips, the operator drawing the spray rod across the bog with a raking motion. The dusts were applied with the ordinary type of two-wheeled small power duster. A canvas was fastened over the four dust nozzles and trailed some twelve feet behind while in operation. Two applications of all treatments were made, the first when two-thirds of the blossom petals had fallen and the second twelve days later.

At picking time samples of cranberries were examined for evidences of the insect, each sample including all the berries picked within a circle twenty inches in diameter. The samples were located fifteen feet from all plot margins and fifteen feet from each other, there being, therefore, nine samples in each treated plot. Only three samples were taken from the untreated area as it was quite small.

The results expressed in Table I show that the treated plots had lower infestations than the untreated plot and that the synthetic cryolite-gypsum dust was more effective than the nicotine sulphate or rotenone treatments. In the analysis of results of all plots the untreated plot is not significantly different from plots 2 and 3. Plots 4 and 5 are, however, significantly different from plots 1, 2 and 3. In comparing the treated plots only, plot 5, the synthetic cryolite-gypsum dust plot, shows a significant difference from plots 2, 3 and 4. There is no significant difference among plots 2, 3 and 4. It is unfortunate that more samples were not taken from the untreated plot but circumstances did not permit the establishment of this plot on an equal basis with the others.

In the season of 1940, four treatments were again applied in this bog for comparative control of the fruit worm. All procedure was the same as in the previous season except that the untreated plot was located across the centre of the bog instead of at one end. It was decided to test the synthetic cryolite again and compare it with natural cryolite. Nicotine sulphate was used at the same strength but in combination with 2-6-40 Bordeaux. Natural cryolite was also used in combination with sulphur at 70-30 strength. The plots ran in sequence as follows: plot (1) nicotine-Bordeaux spray; plot (2) natural cryolite; plot (3) check; plot (4) synthetic cryolite; and plot (5) 70-30 sulphur and natural cryolite. As in the previous year two applications were made, the first when two-thirds of the blossom petals had fallen and the second ten days later.

The results in Table 2 show that all treated plots had lower infestations than the untreated plot and that again as in 1939 the synthetic cryolite had given the greatest protection. The difference in the average percentage of infestation between the treated and untreated plots is shown to be significant. Plot 4, the synthetic cryolite plot, shows a significant difference from the other treated plots which, however, show no significant difference among themselves.

Summary

Results of dusting and spraying tests carried on in 1939 in a cranberry bog infested with the cranberry fruit worm show that a combination of 50 per cent synthetic cryolite and 50 per cent gypsum gave a more effective control than other materials tested. It was also shown that a 2 per cent rotenone spray was more effective than a 2 per cent rotenone dust. A spray of nicotine sulphate was the least effective but resulted in considerably less infestation than in the untreated plot. In 1940 synthetic cryolite again gave the most effective control while nicotine sulphate in combination with 2-6-40 Bordeaux gave second best control. Undiluted natural cryolite and 70-30 sulphur-natural cryolite gave approximately the same degree of control which was only slightly inferior to the nicotine sulphate Bordeaux combination.

TABLE I.

Cranberry Fruit Worm Control; 1939 Experiments.

Sample No.	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5	
	Untreated		Nicotine sulphate spray		2% rotenone gypsum dust		2% rotenone spray		50% synthetic cryolite gypsum dust	
	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested
1	58	18.9	93	38.7	102	17.6	140	7.8	253	9.4
2	60	51.7	97	18.5	123	3.9	125	16.0	366	4.9
3	60	46.7	128	26.8	50	16.0	88	21.6	270	11.5
4			110	12.7	51	19.6	114	10.5	225	5.8
5			141	9.2	91	12.1	115	13.9	105	4.8
6			107	28.0	93	27.9	95	17.9	264	2.6
7			129	20.1	139	22.3	180	10.0	164	5.5
8			59	18.6	29	20.6	135	6.7	94	4.2
9			133	6.0	147	14.3	158	13.3	234	4.7
Av. no. berries per sample	59.3		110.0		91.7		127.8		219.4	
Av. % infested		39.09		19.87		17.14		13.08		5.93
Standard Deviation	17.6143		10.1952		6.8252		4.8660		2.7517	
S. D. of the mean	10.1693		3.3984		2.2751		1.6220		.9172	
Difference required for significance between untreated and treated plots			23.88 (no significant difference)		23.21 (no significant difference)		22.92 (significant difference)		22.72 (significant difference)	

TABLE II.

Cranberry Fruit Worm Control; 1940 Experiments.

Sample No.	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5	
	Nicotine Bordeaux spray		Natural cryolite		Untreated		Synthetic cryolite		70-30 Sulphur natural cryolite	
	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested	Berries Examined	% Infested
1	358	13.4	250	18.0	252	43.6	273	5.8	217	11.9
2	310	18.7	607	6.5	404	27.7	81	14.8	351	19.6
3	252	15.8	460	5.0	242	52.4	296	5.7	163	15.9
4	275	8.3	64	26.5	235	63.8	227	4.8	151	12.5
5	164	10.9	345	20.5			345	10.7	177	18.6
6	283	8.8	209	25.3			382	5.2	256	12.5
7	143	27.9	350	7.4			327	4.8	151	26.4
8	341	8.7	361	21.0			349	10.0	125	20.0
9	191	13.0	357	9.5			283	8.8	233	6.0
Av. no. berries per sample	257.4		333.7		283.2		284.8		202.6	
Av. % infested		13.99		15.61		46.91		7.88		15.98
Standard Deviation	6.2931		8.5267		15.2287		3.4539		5.9816	
S. D. of the mean	2.0977		2.8422		7.6143		1.1513		1.9939	
Difference required for significance between untreated and treated plots	17.36 (significant difference)		16.48 (significant difference)				16.94 (significant difference)		17.32 (significant difference)	

AN IMPROVED METHOD IN THE PRESERVATION OF CONIFEROUS FOLIAGE FOR EXHIBITION PURPOSES*

By Henri Raizenne

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Of the various methods at present in use for the preservation of coniferous foliage for exhibition purposes, there is none which fully solves the problem of keeping the needles fresh and preserving their original colour. To the long list of preservatives already in use, I should like to add another which I have found most useful.

A perfect preservative must give the following results: First, replace the sap in such a manner that the fresh needles will not drop from the twig and the bark will not break; second, cause the treated needles to remain permanently attached to the stem.

At the present time, there is no known preservative which will perform both these functions. It is, therefore, necessary to carry out the operations of pickling and dipping separately.

The fluid which replaces the sap in the foliage must be miscible with the sap and its specific gravity must be higher than that of the sap (approximately 1.004). Glycerine ($CH_2OH.CHOH.CH_2OH$ sp. gr., 1.26) has been the base of nearly all such preservatives because it fulfills the above requirements. It has, however, the disadvantage of slow penetration.

The most commonly used pickle having a glycerine base is made as follows:

$$\left.\begin{array}{r l} 60 & \text{parts of Water} \\ 39 & \text{parts of Glycerine} \\ 1 & \text{part of Formaldehyde} \end{array}\right\} \text{sp. gr. } 1.091$$

While conducting some experiments I came across a substitute for glycerine, namely ethylene glycol ($CH_2OH.CH_2OH$ sp. gr., 1.115) which has proved to be decidedly superior to the former substance. It has a much more rapid penetration than glycerine because the penetration of wood by any fluid is usually proportional to the viscosity of the said fluid and greatly reduces the time necessary for this process. Although it is about three times as expensive as glycerine, it can be recommended as excellent for the purpose mentioned. The pickle is made up as follows:

$$\left.\begin{array}{r l} 65 & \text{parts of Ethylene Glycol} \\ 34 & \text{parts of Water} \\ 1 & \text{part of Carbolic Acid or Formaldehyde} \end{array}\right\} \text{sp. gr. } 1.029$$

When foliage is treated with the glycerine solution, it should be allowed to remain in it at least one month. Two weeks is sufficient for the ethylene glycol solution. After it is ready for the next operation, i.e., the "dipping" process, the following method has been found to be the most valuable.

When the treated specimen is taken from the pickling solution, it should be shaken gently to get rid of excess fluid, then dipped while still wet in the "dipping" solution which deposits a thin film at the base of the needles, thus holding them in place.

*Contribution No. 2052, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

The dipping solution is made up as follows: four full sheets of gelatine (30 sheets per pound) are dissolved slowly in 12 ounces of cold water to which has been added a few drops of carbolic acid. This can be kept as a stock solution and if found too thick for use, can be thinned to proper consistency by warming slightly. While it is still warm, dip the foliage once or twice, being sure to shake it well after each dipping, otherwise a film will form between the needles. After a few days, the needles can be painted with oil colours.

I have found that the foliage becomes brittle after a year. This can be remedied by adding a few cubic centimeters of glycerine in the "dipping" process to render the needles more flexible.

Points to remember.—(1) Always use fresh foliage; (2) make certain that the foliage remains in the preserving or pickling solution the maximum length of time; (3) shake the foliage well between the preserving and dipping solutions and between each dipping; and, (4) do not use thick oil paints in painting the needles. The colour should be applied from the base of the needle towards the tip.

A NOTE ON THE GROSS ESTIMATE OF FOREST INSECT DAMAGE IN CANADA*

By A. W. A. Brown

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The following is an abstract of a paper presented at the Annual Meeting, and published in the Forestry Chronicle, Vol. 16, No. 4.

In recent years, workers in forest entomology have become increasingly cautious in advancing any quantitative estimate of forest insect damage, and as a result we have had no concrete basis for a picture of the relative importance of the major infestations. It is considered that any attempt to derive a figure is better than none at all, if only to serve as a basis for criticism.

The essentials required to obtain an approximate estimate are as follows:

1. Maps showing the extent and intensity of the infestation; derived from activities of field laboratories and of the Forest Insect Survey.
2. Estimate of the volume of the various tree species over unit areas; available in forest inventories published by the forest services of the Dominion and several provinces.
3. Sample plots in the area of infestation; about 1/10 of an acre in size, and covering the various conditions on the ground.

Using these basic figures, now obtainable from various sources, and of variable accuracy, a figure for mortality is derived for 11 of the most destructive species. This damage being cumulative, it is necessary first to estimate the mortality since the infestation began, and then derive the annual figure by subtraction of the previous year's figure or by arbitrary estimate.

By these methods, the total figure for annual damage by these 11 species amounted to 2,680,800 cords, or 300 million cubic feet. The most destructive forest insects in 1939 proved to be, by these calculations, the bronze birch borer, *Agrilus anxius* Gory, (981,000 cords), the jack pine budworm, a biological strain of the spruce budworm, *Cacoecia fumiferana* Clem., (700,000 cords), the spruce budworm (452,000 cords), and the European spruce sawfly, *Gilpinia polytoma* (Htg.) (385,000 cords). It is considered that the total annual forest insect damage, including all species and taking loss of increment into account, may be from 600 to 700 million cubic feet.

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*Contribution No. 2057, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

A SUMMARY STATEMENT CONCERNING SOME OF THE MORE IMPORTANT INSECT PESTS IN CANADA IN 1940*†

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Field Crop and Garden Insects

The grasshopper outbreak in the Prairie Provinces continued with reduced severity in 1940. The heaviest infestations developed in southwestern Saskatchewan and southeastern Alberta. The important species in these two provinces were the lesser migratory grasshopper, *Melanoplus mexicanus* Saus., *M. packardi* Scud., and the two-striped grasshopper, *M. bivittatus* Say. The clear-winged grasshopper, *Camnula pellucida* Scud., was comparatively scarce, except locally. In Manitoba, the latter species was dominant. Further details follow.

The grasshopper population in Manitoba increased considerably during the 1940 season, particularly in the southern part of the Red River valley where the infestation developed to the severe category. A moderate infestation extended over most of south-central Manitoba, north to the Assiniboine and northwestward to about Virden. Southwestern Manitoba and the remainder of the grasshopper area of the province carried a light infestation, with severe and moderate areas north of Winnipeg. Damage was very low considering the abundance of grasshoppers, thanks to rains at critical periods.

In Saskatchewan, the grasshopper infestation was much lighter than had been expected. The insects were most numerous in the southwestern portion of the province where, in the Claydon-Robsart-Govanlock area, hundreds of square miles of crops were destroyed and pastures were heavily damaged. Enormous numbers of grasshoppers were poisoned in the control campaign, and this evidently greatly reduced the concentration of flights originating in this region. At the end of the season surveys indicated that there were no severely infested areas remaining in Saskatchewan, and the province is expected to be free from heavy outbreaks in 1941.

In Alberta, the outbreak was most intense in the southeast, where the majority of stubble crops were destroyed and others seriously damaged. Migrations occurred in July and August and the insects spread over much of the southern portion of the province and caused some losses to wheat, oats, and barley. Much greater losses were prevented by abundant and timely rainfall. Surveys failed to reveal any localities where the grasshoppers had settled to lay eggs, and it appears probable that, in spite of the extensive and prolonged dispersal flights, the grasshopper problem will be a comparatively minor one in Alberta in 1941..

Elsewhere in the Dominion there were no important outbreaks of grasshoppers. However, increased numbers were reported in Nova Scotia, New Brunswick and sections of Quebec.

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*Prepared at the direction of the Dominion Entomologist from regional reports submitted by officers of the Division of Entomology, and members of the Entomological Society of Ontario. The original reports may be referred to in the first issue of Volume 19, of the Canadian Insect Pest Review.

†Contribution No. 2061, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

In general, cutworms were moderate or few in numbers during 1940 throughout the Dominion except British Columbia. In that province, 1940 was one of the worst cutworm years on record, and reports of severe damage were received from many points. The species involved on Vancouver Island, and on the lower mainland and coastal areas to the north was the variegated cutworm, *Peridroma margaritosa saucia* Haw. Potatoes, peas, and general truck crops were totally defoliated in many cases.

Small, localized outbreaks of the armyworm, *Leucania unipuncta* Haw., occurred in Nova Scotia, New Brunswick, Ontario, Manitoba, and Saskatchewan. Oats, corn and millet were among the crops attacked.

Heavy damage to crops was caused by wireworms especially *Ludius aereipennis destructor* Brown, in southern and central Saskatchewan and southwestern Manitoba. The damage was much worse to wheat planted on land fallowed in 1939 than to other grain crops. Wheat on summer-fallow in north-central Saskatchewan, and in parts of northeast Saskatchewan between Saskatoon and Humboldt also suffered severely. Wireworms were also present in wheat fields throughout much of Alberta. However, except for one or two localities in the south, and an area in the Peace River district, losses were not serious.

Increased abundance of, and damage by, the wheat stem sawfly, *Cephus cinctus* Nort., occurred in Saskatchewan and Alberta during the 1940 season. Heavy damage was observed in south-central Saskatchewan in lighter soil areas where summer-fallowing had been infrequent. Reports indicated that the loss caused by this insect was unusually high in proportion to infestation, because wheat was left standing until dead ripe. In Alberta, favourable weather conditions during the flight period enabled the adults to disperse widely from their points of emergence, with the result that large fields of wheat became generally infested instead of only in the margins. The area of infestation also increased, so that a large part of the province south of Wainright was affected. Total damage was much greater than for many years past, as heavy rains and winds knocked flat on the ground most of the wheat stems cut by the insects. Fields left for combining suffered particularly heavy losses. In Manitoba, light damage by the wheat stem sawfly occurred from Crystal City west to the Saskatchewan boundary, and north to the Assiniboine river.

Adults of the eastern wheat stem sawfly, *Cephus pygmaeus* L., emerged in considerable numbers in eastern Ontario during June. However, there appeared to be a decrease in the number of fields affected in comparison with 1939.

In the Edmonton region of Alberta there was an increase in the numbers and distribution of the hessian fly, *Phytophaga destructor* Say. Damage was not serious, but the presence of the insect was conspicuous at many points. The hessian fly was first reported in this region in 1938, when it was taken at Kinsella.

A numerous and widespread flight of June beetles (*Phyllophaga* spp.) occurred during 1940 over southern and central Quebec and in the Oshawa and Niagara districts of Ontario, where they defoliated shade trees and deposited immense numbers of eggs. In the latter districts thousands of ash and poplar trees were completely defoliated, and other deciduous species were partially defoliated. Over the greater part of Ontario June beetle larvae, or white grubs, were in the third-year stage, changing to beetles late in the season. Consequently, white grub damage was slight. In the Oka-St. Jerome-Montreal region of Quebec, however, the white grubs were present in abundance in the second-year stage and caused serious damage in market gardens and to field crops and pastures.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, was apparently less troublesome than usual in Eastern Canada, except locally as in the Ottawa

district, Ontario, and around St. Johns and Lac St. Jean, Province of Quebec. In Manitoba, it was reported that, owing to heavy winter mortality due to lack of snowfall, damage did not become evident until August and little poisoning was necessary. Farther west, however, in Saskatchewan and Alberta, the species was unusually abundant. In southeastern British Columbia, which includes the western limits of this species in Canada, the beetles were present in smaller numbers than was the case during the preceding three years.

Various species of flea beetles took their usual annual toll. The potato flea beetle, *Epitrix cucumeris* Harr., occurred in moderate to severe numbers in Nova Scotia, and was average in New Brunswick until early September, when abundant summer generation adults appeared. Local damage by this species occurred in Quebec and Ontario. In Manitoba the crucifer flea beetle, *Phyllotreta lewisi* Cr., was again destructive to various cruciferous plants in market gardens in the Winnipeg and Brandon districts. Flea beetle species also caused losses in gardens and market gardens at Saskatoon and other localities in Saskatchewan. Slight damage to small sugar beets by the hop flea beetle, *Psylliodes punctulata* Melsh, occurred in several irrigated areas in Alberta. In British Columbia, flea beetles were numerous and damaged young plantings; in the Inonoaklin Valley, 90 per cent of small crops were attacked. The cabbage flea beetle, *Phyllotreta albionica* Lec., was the species prevalent on Vancouver Island.

The sweet clover weevil, *Sitona cylindricollis* Fab., was prevalent throughout Manitoba and central and eastern Ontario, but damage was less severe than in 1939. In Manitoba, where it was first found in outbreak numbers in 1939, damage occurred from the United States boundary north to the Swan River valley. This was most severe in northern, interlake, and eastern drought areas, where, in some districts, farmers reseeded with corn or millet to assure a crop of fodder. In Alberta a related species, *Sitona tibialis* Hbst., was more abundant in alfalfa fields early in the season than it had been for several years past. However, no appreciable damage was done.

Heavy infestations of the clover seed chalcid, *Bruchophagus gibbus* Boh., (formerly known as *B. funebris* Howard) were found for the first time in Manitoba. These occurred on alfalfa in the area between Lake Winnipeg and Lake Manitoba, and in the Winnipeg district. In some fields the insects destroyed a large percentage of the seed. The species was heavily parasitized by *Habrocytus medicaginis* Gahan.

The alfalfa looper, *Autographa californica* Speyer, was abundant in Alberta, in districts where alfalfa or clover was grown. In the Peace River district the larvae occurred in alfalfa and clover fields, but caused no serious damage, but in irrigated sections of southern Alberta some alfalfa fields were partially defoliated.

The species *Lygus elisus* Van D., was abundant in alfalfa fields in irrigated sections of southern Alberta and in the Peace River district. It is considered important wherever seed is produced, because it feeds on the blossoms and green seed.

Blister beeltes were reported locally numerous at various points in Eastern Canada, but, in most cases, damage by them was not important. Potatoes principally were attacked. The insects were also unusually abundant throughtout the three Prairie Provinces, causing damage to garden and field crops and ornamentals. Several species were involved.

The cabbage maggot, *Hylemyia brassicae* Bouche, was reported locally abundant and injurious in Quebec, somewhat more numerous than in 1939 in central Ontario, and occurring in general but light infestations in southern Alberta. The

onion maggot, *H. antiqua* Mgn., was locally severe in southern Quebec and eastern Ontario; about the same as in 1939 in central and southwestern Ontario, and in average, moderate numbers in Manitoba and Alberta.

From Nova Scotia to Saskatchewan reports indicate that the imported cabbage worm, *Pieris rapae* L., was conspicuously abundant during 1940 and caused heavy losses of cruciferous crops where insecticides were not used. In Alberta damage was reported as not so generally severe as usual.

The diamond-back moth, *Plutella maculipennis* Curtis, occurred in outbreak numbers in Manitoba and Alberta, particularly in the area north and east of Calgary, Alberta, where fields of rape and turnips were almost defoliated, and in the Selkirk-Winnipeg districts, Manitoba, where nearly 100 per cent of cabbages were infested. The species was also quite injurious in several districts in southern Quebec.

In the Victoria district, British Columbia, the cabbage seed weevil, *Ceutorhynchus assimilis* Payk., was destructive to cabbage and swede turnip grown for seed.

In the interior of British Columbia, the onion thrips, *Thrips tabaci* Lind., was more abundant than for many years, possibly owing to extremely hot, dry weather. Severe damage was done in onion-growing sections of the Okanagan and Thompson River valleys. In Manitoba, the species was less abundant in the Winnipeg area than in 1939. In southwestern Ontario, some onion fields again suffered considerable damage by the thrips.

The European corn borer, *Pyrausta nubilalis* Hbn., greatly increased during 1940 in corn-growing regions of Ontario and Quebec and rendered much sweet and canning corn unfit for use. The stalk infestation in field corn in southern Ontario was unusually heavy, being about twice or three times that of 1939. In addition to corn, other plants were attacked including gladiolus, millet, potato and hops, but these infestations were not of economic significance. The increase of the corn borer is associated with weather conditions favourable to its development.

The corn ear worm, *Heliothis obsoleta* Fab., was reported in several localities in the interior of British Columbia indicating a more than usual abundance. A local infestation developed on early sweet corn at Maugerville, New Brunswick. Elsewhere in the Dominion the species was apparently scarce or absent.

One of the most widespread and general outbreaks of the beet webworm, *Loxostege sticticalis* L., yet recorded occurred throughout the Prairie Provinces during 1940, including the whole of Manitoba, Saskatchewan and Alberta, and involving the entire Peace River district. Many kinds of plants were attacked including sugar beets, alfalfa, sweet clover, flax, various garden plants, shrubs, shade trees, and weeds. In Manitoba, the outbreak coincided with the first year of commercial production of sugar beets in the Red River valley, but although serious defoliation took place, the plants put on new growth and the sugar yield was good.

Following the discovery in 1939 of an infestation of the sugar beet nematode, *Heterodera schachtii* Schmidt, near Sarnia, Ontario, surveys were made in 1940 of the main sugar beet area in the province. These revealed six infested fields grouped in a small area near Sarnia. Steps to prevent the spread of the pest have been taken.

The tarnished plant bug, *Lygus pratensis* L., was reported numerous on vegetables and flowering plants in gardens in Nova Scotia, and on celery and potatoes in the Montreal district, P.Q. In Ontario, early mangels and ornamental plants suffered considerable injury after mid-summer.

Say's stink bug, *Chlorochroa sayi* Stahl., was present over most of Alberta south of Calgary, with several new localities showing a marked increase in numbers. General areas of severe infestation were smaller than in previous years, but there were more of them, and losses ran as high as 20 per cent of the crop.

In the Vancouver district, B.C., the European earwig, *Forficula auricularia* L., was reported early in summer to have increased in numbers, probably as a result of a mild winter. In the Victoria district, on the other hand, many reports were received of the scarcity of this pest. A reduction of the earwig population as a result of control measures was reported at Ayton, Ontario, where it was first discovered in 1938.

An infestation of the pea aphid, *Illinoia pisi* Kalt., affecting over 1000 acres of canning and seed peas in the Taber-Barnwell district in the irrigated sections of southern Alberta was the most severe on record for that area. The species was also abundant in pea-growing areas of the Lower Fraser valley, where damage was slight owing to natural control factors, and in localities in eastern Ontario and southern Quebec.

The average pod infestation by the pea moth, *Laspeyresia nigricana* Steph., in the Lower Fraser valley, B.C., was about 30 per cent, or rather higher than in 1939. In the Gaspe, Quebec, there was a great reduction in infestation as compared with 1939.

The carrot rust fly, *Psila rosae* Fab., increased in range and intensity of infestation on Vancouver Island and throughout the Lower Fraser valley, British Columbia. Severe damage to carrots occured in many localities, in some cases complete crop loss being sustained.

The weevil, *Brachyrhinus singularis* L., discovered in the Victoria district, British Columbia, in 1937, has greatly increased and has become a serious pest of garden plants, of which it attacks a large variety.

During August and September, 1940, an infestation of the Japanese beetle, *Popillia japonica* Newm., was found for the first time in Canada. This was in a rose garden in Queen Victoria Park, Niagara Falls, Ontario, where 18 females and 14 males of the species were taken, largely on hybrid tea roses, but occasionally on dahlia blooms.

Fruit Insects

Reports indicate that the codling moth, *Carpocapsa pomonella* L., was present in somewhat increased abundance in various apple-growing districts of the Maritime Provinces, Quebec, and British Columbia. In Ontario, however, a backward spring, frequent rains, and lower temperatures reduced injury by this species.

In Nova Scotia and New Brunswick, the apple maggot, *Rhagoletis pomonella* Walsh, was not so prevalent as in 1939, and there was a marked reduction of infested orchards within provincial control zones. In Ontario, weather conditions were apparently favourable to the species, the frequent rains facilitating emergence and maintenance of the flies, and interfering with the application and effectiveness of arsenical sprays.

The rosy aphid, *Anuraphis roseus* Baker, was unusually scarce in Nova Scotia orchards in the spring of 1940, and caused very little injury to the apple crop. In Ontario its numbers in most places were about normal. However, commercial damage was reported in a few orchards in the eastern part of the province, and the species was also more prevalent than usual in Norfolk county. The green apple aphid, *Aphis pomi* DeG., threatened a bad outbreak in Ontario orchards, but was checked by predators and probably other natural control factors. It was below normal in numbers in Nova Scotia. The woolly apple aphid, *Eriosoma lanigera* Hausm., also showed a decided decline in the latter province.

Although heavy flights of moths of the gray-banded leaf roller, *Argyrotaenia mariana* Fern., were reported in some Nova Scotia orchards, the species in general showed a decline. Other species of leaf rollers occurred only in small numbers in the province. In Ontario, the fruit tree leaf roller, *Archips argyrospila* Wlk., was again abundant in some apple orchards in Northumberland and Prince Edward counties, and showed an increase in Norfolk county. In Quebec, an outbreak of leaf rollers occurred in some orchards at St. Hilaire, and the insects were quite numerous in the Shefford and Brome districts.

The eye-spotted budmoth, *Spilonota ocellana* D. & S., caused much damage to the apple crop in many orchards in Nova Scotia. In some districts it showed some increase while in others there was probably very little change. In New Brunswick it continued prevalent in the Springhill area. In Ontario, it was again a major pest. Blossoms, foliage and fruit were damaged quite severely in many orchards in eastern Ontario, and the species was also troublesome in Norfolk county in southern Ontario.

Tree hoppers were fairly abundant in many orchards in Nova Scotia and caused considerable damage to small trees in some new plantings. *Ceresa bubalus* Fab., and *C. taurina* Fitch were the most commonly found species; *C. basalis* Walker was present in fair numbers, and *Glossonotus crataegi* Fitch showed a decline in the Berwick district where it was fairly abundant in 1939. The buffalo tree hopper, *C. bubalus* Fab., was also reported common in eastern Ontario.

There was a decline in abundance of the white apple leafhopper, *Typhlocyba pomaria* McAtee, in apple orchards in Nova Scotia, Ontario and British Columbia. The reduction in numbers was especially marked in Ontario where control measures were unnecessary. In one orchard at Vineland egg parasites were found to have played an important part in destroying the pest. In the Niagara district, Ontario, the potato leafhopper, *Empoasca fabae* Harris, was about two weeks later than usual in appearing in injurious numbers, but the ultimate infestation on plum and apple nursery stock was fairly heavy and caused considerable injury.

The mullein leaf bug, *Campylomma verbasci* Meyer, was abundant in a large apple orchard at Queenston, Ont., and caused considerable damage by scarring the fruit, some of which dropped prematurely. It was also troublesome in a few orchards in the Annapolis valley, Nova Scotia, but, although more numerous than last year, was less abundant than in 1938.

The European red mite, *Paratetranychus pilosus* C. & F., was less in evidence in Nova Scotia orchards than during past seasons, and few orchards suffered more than minor losses from it. In Ontario, the species was fairly abundant on apple and plum in the Niagara district, and on apple in Norfolk county. In south-western Ontario it was injurious in many apple orchards. In the Okanagan valley, British Columbia, although very numerous in a few orchards it was generally no more troublesome than usual.

The area of infestation of the Pacific mite, *Tetranychus pacificus* McG., which was discovered in British Columbia for the first time in July, 1939, is spreading at Oliver, B.C., and the mite now occurs at Kaleden, twenty miles north of Oliver.

The oyster shell scale, *Lepidosaphes ulmi* L., was very scarce in the Okanagan valley, British Columbia, owing to the large numbers destroyed by unusually hot weather at hatching time in 1939. In Nova Scotia a general and, in some cases, heavy, increase of this species was reported.

The tarnished plant bug, *Lygus pratensis* L., was fairly abundant in Nova Scotia and caused slight oviposition injuries to apples. In the Niagara district, Ontario, it was present in considerable numbers, and peach nursery stock was

badly damaged by it, over 95 per cent of the trees in some nurseries suffering "stop-back" injury. Plum and, to a lesser extent, apple stocks were also freely attacked.

Injury by the pear slug, *Caliroa limacina* Retz., was slight in southern Ontario, even on unsprayed trees. In British Columbia, this species was present in injurious numbers on young pear trees at Keremeos and Oliver in the Okanagan valley, and on pear, cherry and other hosts at Victoria, Vancouver and in the Lower Fraser valley.

Summer outbreaks of the pear psylla, *Psyllia pyricola* Forst., developed on a few neglected or poorly sprayed orchards in the Niagara district. In this region, too, minor outbreaks of the green soldier bug, *Acrosternum hilare* Say, caused some local injury to the fruit of pears.

Reports of injury by the round-headed apple tree borer, *Saperda candida* Fab., were quite numerous from the Frelighsburg, Aylmer, Charlebourg and Quebec districts of the Province of Quebec. In Ontario, where the species is rarely troublesome, an apple orchard in Norfolk county was damaged.

The infestation of black cherry aphid, *Myzus cerasi* Fab., was moderate on unsprayed and poorly sprayed sweet cherry trees in the Niagara district, Ontario. Control practices have markedly diminished aphid injury on cherries in recent years.

Although peach twig injury by first and second brood larvae of the oriental fruit moth, *Grapholitha molesta* Busck., was unusually heavy in most parts of the Niagara peninsula, Ontario, high parasitism by *Macrocentrus ancylivorus* Roh., prevented the fruit infestation from reaching the proportions expected, in spite of favourable weather conditions. However, in general, fruit injury was greater than for several years past. In many orchards delayed harvesting of Elberta peaches allowed considerable injury by third brood larvae. In southwestern Ontario the development of the infestation was somewhat similar, but parasitism by the native *Glypta rufiscutellaris* Cress. was also heavy.

In general, the peach tree borer, *Sanninoidea exitiosa* Say, was less troublesome than formerly in peach orchards in Ontario, probably because many growers are now using effective control measures. Nursery stock in some sections was damaged, however. In British Colubmia, a borer reared from peach trees at Peachland was found to be *S. graefi var. barnesi* Beut. It is apparently common in the Okanagan valley, and probably has previously been mistaken for *S. exitiosa*.

The cranberry fruit worm, *Mineola vaccinii* Riley, was again prevalent in cranberry bogs in Nova Scotia and along the northern and eastern coastal areas of New Brunswick, and caused considerable loss of fruit. On cranberry bogs and blueberry barrens in western Nova Scotia and in Kent county, New Brunswick, the chain-spotted geometer, *Cingilia catenaria* Drury, occurred in outbreak numbers and caused much damage. Another species, the black-headed fireworm, *Rhopobota naevana* Hbn., was reported doing serious damage to cranberries in the Rusagonis area of New Brunswick.

Grape leafhoppers, *Erythroneura* spp., increased somewhat over 1939 in vineyards in the Niagara district, Ont.

Reports of damage to currants and gooseberries by the imported currant worm, *Nematus ribesii* Scop., were received from many localities in Quebec, Manitoba and Saskatchewan.

The strawberry weevil, *Anthonomus signatus* Say, was prevalent in the Grand Lake, Washademoak and Bellisle strawberry-growing districts of New Brunswick, and serious damage was done to many two-year old plantations. This insect was

also responsible for considerable damage in the Fredericton area. In Nova Scotia, some decrease over 1939 was indicated generally. Severe attacks by this species were reported in a number of localities in Quebec. In southern Ontario, where the insect has been of minor importance for some years, a few enquiries about its control were received from growers in the Jordan-Beamsville district.

The strawberry root worm, *Paria canella* Fab., was abundant in some strawberry plantations in Nova Scotia, New Brunswick and the Niagara district, Ontario.

A small black weevil, *Auletobius congruus* Walk., damaged some strawberry patches at Salmon Arm, British Columbia. On one farm 35 per cent of the blossoms on one-half an acre were destroyed and there was some damage on about four acres. This appears to be the first record of economic damage in the province by this species.

Forest and Shade Tree Insects

The European spruce sawfly, *Gilpinia polytoma* Htg., increased to some extent in the central Gaspe area of Quebec, where emergence of adults was unusually high and control by disease and parasites was not very important. Larval disease appeared, however, on the upper reaches of the Cascapedia River in the autumn, and recoveries indicated a further increase of parasitism by *Exenterus* sp. Spruce continued to die, and mortality, so far, on the head of the Cascapedia and Ste. Anne drainages was indicated to be 75 per cent by volume of white spruce, and 45 per cent by volume of black spruce, including trees attacked by the eastern spruce bark beetle. Throughout the remainder of the infested area in the Maritime Provinces and eastern Quebec the sawfly population was considerably reduced. The number of overwintering cocoons throughout a large part of the two-generation area had been cut down by the activities of parasites and disease in 1939, and, in 1940, the disease was more effective and widespread, and caused high larval mortality in both heavily and lightly infested areas. In Ontario new distribution records were obtained in Gray and Bruce counties.

The area in which noticeable defoliation by the spruce budworm, *Archips fumiferana* Clem., has occurred increased greatly and now extends from Pembroke to Michipicoten in the Algoma region, and from south of Huntsville to the vicinity of Laniel and Chapleau on the north. The area of heavy infestation centred around the Mississagi Forest Reserve, is apparently spreading, and other such areas have appeared here and there in the light to moderately infested sections. It is expected that the outbreak will continue. A heavy infestation was present in the Spruce Woods Forest Reserve, near Onah, Manitoba, and, in British Columbia, 1940 was reported to be a peak year for this species, extensive defoliation occurring, especially in the Barkerville area. The jack pine budworm, considered to be a biological race of the foregoing species, was again active over wide expanses of forest in northern Saskatchewan, Manitoba and northwestern Ontario. Its eastern limits reach the lake-head country in the vicinity of Port Arthur. During 1940, it was most active in the Fort a la Corne Forest Reserve of Saskatchewan, the Spruce Woods Forest Reserve in Manitoba, and in the Port Arthur region of Ontario.

The jack pine sawfly, *Neodiprion banksiana* Harr., was active throughout the range of jack pine in central Canada, but the amount of defoliation was generally less than in 1939, and the fear that it might reach serious proportions in the areas already weakened by the budworm is considerably less than in 1939.

The larch sawfly, *Pristiphora erichsoni* Htg., was reduced in numbers throughout New Brunswick, noticeable defoliation occurring only locally in Charlotte county. About 80 per cent parasitism by *Mesoleius tenthredinis* L. and *Bessa selecta* Mgn. was general. Some defoliation was observed on Prince Edward Island,

and there was a definite increase of the species in Nova Scotia, where parasitism was considerably less and stands of larch were heavily to completely defoliated in Colchester, Cumberland and Pictou counties. Local fluctuations in abundance were observed in western Quebec and in Ontario but, in general, the infestation appeared somewhat less serious than in 1939 in the former area, and definitely heavier in the latter region. The parasite *Mesoleius* which was liberated in this territory in 1939 appeared to have established itself. Farther west, the larch sawfly was reported to be an increasing hazard to larch throughout central Canada. A considerable increase was noted in the Riding Mountains of Manitoba and small incipient outbreaks were found in isolated regions. No *Mesoleius* parasites were recovered. In British Columbia, the sawfly continued active in the Fernie- Crowsnest Pass area, but was less abundant from there to Kootenay Lake. Its known range was extended westward to near Whatshan Lakes, north of Needles in the Columbia River district, where larch over an area of eight square miles was defoliated.

The larch case bearer, *Coleophora laricella* Hbn., was comparatively scarce in New Brunswick and numerous in Nova Scotia. Throughout the latter province most stands showed partial to complete browning of the foliage in early summer. Ornamental larch at Berthierville, Quebec, suffered severe defoliation.

The bronze birch borer, *Agrilus anxius* Gory, continued its activities as a widespread and destructive pest. In New Brunswick, branches and trees in all types of stands continued to die from its attacks. However, the insect was considered probably somewhat less numerous than in 1939. Injury was reported in the northern counties of New Brunswick and in Cumberland county, Nova Scotia, indicating that the outbreak area may have been extended. Lumber, veneer and fuel resources from birch have been seriously depleted in central and southern New Brunswick, where most of the mature stands are dying out. The more valuable trees may be salvaged in areas of good birch growth owing to the increased demand for veneer for manufacturing aeroplanes. In northwestern Ontario, particularly in the country at the head of the Great Lakes, the bronze birch borer seemed much reduced and injury was light. The species continued active, however, in northern Manitoba and Saskatchewan. Poplar as well as birch is attacked.

The beech scale, *Cryptococcus fagi* Bsp., which is heavily infesting most stands of beech in southern New Brunswick, where it has killed many trees, was found to have spread farther north in scattered light to moderately heavy infestations to the head of the Bartholomew River and McNamee. In Nova Scotia, where most of the mature birch has succumbed to the attacks of this insect, the beech scale is much less numerous on remaining trees and many immature stands have recovered.

The jack pine scale, *Toumeyella* sp., reached its greatest abundance in parts of Manitoba in 1939, and was an important pest particularly on the young growth of jack pine. At its peak the scale occurred in large numbers over about 3,000 square miles of forest. In 1940 it was reduced to minor proportions by parasites and predators.

Heavy infestations of the forest tent caterpillar, *Malacosoma disstria* Hbn., continued in Manitoba, Saskatchewan and Alberta, north of the prairies. Except locally, the species was not an injurious pest in Eastern Canada, in 1940.

The satin moth, *Stilpnotia salicis* L., was somewhat reduced in the Maritime Provinces as compared with previous years. However, heavy to complete defoliation of small groups of shade trees occurred at a few scattered points in southern New Brunswick and in Nova Scotia. The infestations in British Columbia continue to be kept at a low level by parasites.

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Ontario Department of Agriculture

Seventy-Second Annual Report

of the

Entomological Society

of Ontario

1941

PRINTED BY ORDER OF
HON. P. M. DEWAN, Minister of Agriculture

ONTARIO

TORONTO
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1942

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FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31ST, 1941

Receipts		*Expenditures*	
Cash on hand in Bank	$ 433.31	Printing Canadian Entomologist	$1,000.00
Dues	276.94	Postage	45.58
Subscriptions	455.40	Bank Exchange	3.95
Advertising	443.95	Honoraria & Stenographic Assistance	280.00
Back Numbers	56.62	Annual Meeting	24.08
Bank Interest & Exchange	19.69	Miscellaneous	13.56
Government Grant	300.00	Balance on hand in Bank	623.71
Miscellaneous	4.97		
	$1,990.88		$1,990.88

Audited and found correct
L. CAESAR
H. W. GOBLE
Auditors

Respectfully submitted

A. W. BAKER
Acting Secretary-Treasurer

Entomological Society of Ontario

REPORT OF THE COUNCIL 1940-1941

The seventy-seventh annual meeting of the Society was held in the Biology Building, Ontario Agricultural College, Guelph, on Thursday and Friday, November 7th and 8th, 1940. There was a large attendance of members and visitors. The meeting of the Council and the regular sessions of the Society were held in the Biological Lecture Room. During the course of the meetings thirty-two papers were presented.

Thursday evening a dinner was held in the College Cafeteria in honour of Professor L. Caesar who had retired in June from active entomological work. About one hundred and thirty members of the Society and friends were present. After the dinner members of the Federal and Provincial agricultural services, representative Canadian and American entomologists, old pupils and colleagues paid tribute to Professor Caesar's work as an entomologist and his sterling qualities as a man. Many telegrams and letters of congratulation and appreciation were received.

The Society was represented by Dr. Arthur Gibson at the opening of the new building of the Natural History Survey at Urbana, Illinois. On this occasion Dr. Gibson carried the greetings of the Society and of Canadian entomologists.

It is the sad duty of the Council to record the death of Mr. Ralph Hopping who has been an active member of the Society since 1916.

We record with sorrow also the deaths of Mr. G. A. Ficht and Mr. Frank Hennessey who at various times have been associated with the work of the Society. Mr. Hennessey's work as an entomological artist is well known.

The Council is honoured in expressing appreciation of the services which are being rendered by those members of the Society who are on active service with His Majesty's forces. It is the hope of the Council that they may be spared to soon return to active entomological work.

The journal of the Society, the Canadian Entomologist, completed its seventy-second volume in December, 1940. This volume of 252 pages illustrated by 16 plates and 33 figures contained 62 articles, 12 book notices and 10 research notes.

These artiles were contributed by fifty-eight authors including writers in eight provinces of the Dominion and fourteen states of the Union and Belgium.

RECORD OF PAPERS PRESENTED AT THE SEVENTY-EIGHTH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, HELD IN TORONTO, ONT., DECEMBER 11-12, 1941.

"Early Entomological History"—Arthur Gibson, Division of Entomology, Ottawa.

"Building Canada's Defense Against Insect Outbreaks'—A. B. Baird, Dominion Parasite Laboratory, Belleville, Ontario.

"The Japanese Beetle Situation in Canada"—L. S. McLaine, Division of Plant Protection, Ottawa.

"Ovipositing Habits of the Dragonfly"—E. M. Walker, Department of Biology, Toronto University, Toronto.

"Some Problems Connected with the Presence of *Heterodera schactii* in Southern Ontario"—A. D. Baker, Division of Entomology, Ottawa.

"A Timing Experiment with Combinations of Mercury Insecticides Used for the Control of the Onion Maggot"—W. G. Matthewman, A. G. Dustan, and A. C. Davis, Division of Entomology, Ottawa.

"The Tolerance of Larvae of *Phlegethontius quinquemaculata* Haw. to Nicotine"—G. Beall, Dominion Entomological Laboratory, Chatham, Ont.

"Possible Significance of the Relative Numbers of Nymphs and Adults of Saltatoria (Orthoptera)"—F. A. Urquhart, Royal Ontario Museum of Zoology.

"Thermal Preference by Pharaoh's Ant as a Guide in Control Work"—J. E. Armand, Dominion Plant Inspection Office, Division of Plant Protection, Toronto, Ontario.

"Scouting for the European Earwig, *Forficula auricularia* in Ontario 1938-1941"—C. Copeland and C. R. Messer, Plant Inspection Office, Division of Plant Protection, Toronto, Ontario.

"A Note on the European Earwig Municipal Baiting Campaign at Ayton, Ontario, 1941"—A. G. McNally, Department of Entomology, O. A. C., Guelph, Ont.

"Official Insect Control Recommendations from the Point of View of the Salesman of Insecticides"—R. E. Cudmore, Canadian Industries Limited, New Westminster, B. C.

"A Preliminary Review of the Insecticides Supply in Canada"—A. W. M. Carter, Division of Plant Products, Dominion Department of Agriculture, Ottawa.

"Laboratory Propagation of Three Species of *Exenterus* parasitic on Sawfly"—Alfred Wilkes, Dominion Parasite Laboratory, Belleville, Ontario.

"Observations on the Adult of *Sandalus niger* Koch in Southern Ontario, Canada"—Stanton D. Hicks, Dominion Plant Inspection Office, Division of Plant Protection, Niagara Falls, Ontario.

"Rise in Temperature Due to Metabolism of Cultured of *Ephestia kuhniella*"—George Wishart, Dominion Parasite Laboratory, Belleville, Ontario.

"The White Grub Situation in Ontario During 1941 and Forecast for 1942"—G. H. Hammond, Division of Entomology, Ottawa.

"Evidence of a Partial Second Generation of the European Corn Borer in Ontario"—D. A. Arnott Dominion Entomological Laboratory, Chatham, Ontario.

"Spraying for the Control of the European Corn Borer in Sweet Corn—A report of the Second Year's Work"—G. M. Stirrett, Dominion Entomological Laboratory, Chatham, Ontario.

"The Corn Borer Situation in Ontario in 1941 With Notes on Hybrid Corn"—R. W. Thompson, Department of Entomology, O. A. C., Guelph, Ontario.

"Observations on the Biology of the Praying Mantis"—H. G. James, Dominion Parasite Laboratory, Belleville, Ontario.

"Comparative Morphology of the Proventriculus in Orthoptera"—W. Judd, Department of Biology, Toronto University, Toronto.

"Five Years' Observations of the Wireworm in Muck of Soil"—J. B. Maltais, Dominion Entomological Laboratory, St. Jean, P. Q.

"The Strawberry Weevil in New Brunswick"—C. W. Maxwell, Dominion Entomological Laboratory, Fredericton, N. B.

"The Relative Susceptibility of the Sexes of *Drosophila melanogaster* Meigh. to Nicotine (Alkaloid) Used as a Contact Insecticide"—F. T. Lord, Dominion Entomological Laboratory Annapolis Royal, N. S.

"Capsid Bug Control with Dormant Sprays"—A. D. Pickett, Dominion Entomological Laboratory, Annapolis Royal, N. S.

"Larva of the genus *Melanolophia;* new description and notes"—W. C. McGuffin, Division of Entomology, Ottawa.

"The Spruce Foliage Worm and the Spruce Cone Worm"—Margaret M. McKay, Division of Entomology, Ottawa.

"Importance of the aphid genus *Cinara* in forest entomology"—G. A. Bradley, Division of Entomology, Ottawa.

"Distribution of forest insect in the Old World and the New"—A. W. A. Brown, Division of Entomology, Ottawa.

JAPANESE BEETLE SITUATION*

By LEONARD S. McLAINE,

Plant Protection Division, Department of Agriculture, Ottawa.

For the past several years the Japanese beetle situation has been discussed before this Society. The reports given up to this time have merely outlined the precautions that the Department of Agriculture has taken in an endeavour to prevent or delay the invasion of this insect. Since the discovery of the Japanese beetle in the vicinity of Philadelphia in 1916, it has gradually spread north and north eastwards and it was realized that the day would eventually come when this insect would cross the international boundary. It was to be hoped, however, that this day would be long delayed. Apart from natural flight which, of course, is impossible to intercept, there has been the danger from invasion by artificial distribution, and by this is meant the insect being carried in commodities of one kind or another or in vehicles or ships to points far outside the infested area. It is not necessary, however, to review in detail all the precautions that have been taken in this preventive work other than to mention that precautionary measures have been in force for over ten years (1930). These included the stationing of inspectors at strategic points during the period of beetle activity in the United States; the examination of products of all kinds entering Canada from the heavily infested areas in the United States; the inspection of coastwise shipping, automobiles, freight cars and aeroplanes; and the placing of Japanese beetle traps at so-called "strategic" points, sucn as railway cars, tourist camps or other locations where it was considered that beetles might possibly have been brought in by one means or another.

During this period of time beetles have been intercepted in products of various kinds and at different points. The odd beetle has also been collected in traps. In carrying out these measures, reference should be made to all the assistance and co-operation that the Department has received from various organizations such as the Royal Canadian Navy, the Royal Canadian Air Force, the various coastwise and interwater way steamship companies, the railways, the Department of National Revenue, commercial aeroplane companies, express companies, importers of all kinds of commodities and by no means least the general public at large. In spite of all these precautions, it is regrettable to note that the Japanese beetle has been found in Canadian territory. In the late summer of 1940, adult beetles were collected in Victoria Park at Niagara Falls, and in the summer of 1941, it was discovered at Windsor, Ontario. During this past season, a total of sixty-four beetles were collected at Niagara Falls and one hundred and eighty-seven at Windsor.

Early in the fall of 1940, the United States Bureau of Entomology and Plant Quarantine was called upon for assistance and advice and soil treating and extensive trapping were recommended. It was too late in the season to make arrangements to carry out soil treating of the infested area, but plans were instituted to do this work in the spring of 1941. Through the co-operation of the Ontario Department of Agriculture and the Niagara Parks Commission, ten acres in the park were treated with five hundred pounds of arsenate of lead mixed with one thousand gallons of water to the acre.

In view of the discovery of additional Japanese beetles this past summer it was decided to extend the area treated, In consequence, twenty additional acres were treated in September. It is the intention to carry out soil treating in the Windsor area next spring.

*Contribution No. 24—Plant Protection Division, Department of Agriculture, Ottawa.


LOU
O R I D
Tampa
Miami
Compiled Dec 10, 1941
H G Carm


KNOWN DISTRIBUTION
OF THE
JAPANESE BEETLE
Regulated Areas
Smaller Regulated Areas with Principal City or Town
Trap Finds Outside Regulated Areas
Canada Trap and Scouting Finds
State and Provincial Boundaries
International Boundary
ONTARIO
QUEBEC
NEW BRUNSWICK
NOVA SCOTIA
MAINE
Bangor
Bar Harbor
Waterville
Montreal
Lake Superior
MICHIGAN
Lake Huron
Lake Michigan
Lake Ontario
Lake Erie
MINNESOTA
WISCONSIN
IOWA
ILLINOIS
INDIANA
OHIO
NEW YORK
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PENNSYLVANIA
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DEL
WEST VIRGINIA
VIRGINIA
KENTUCKY
MISSOURI
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
ARKANSAS
MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
FLORIDA
Chicago
Oak Park
Whiting
South Bend
Elkhart
Warsaw
Fort Wayne
Logansport
Newcastle
Richmond
Indianapolis
St. Louis
E. St. Louis
Bridgeton
Louisville
Detroit
Windsor
Toledo
Norwalk
Bucyrus
Mansfield
Newark
Columbus
New Concord
Zanesville
Athens
Marietta
Belpre
Cincinnati
Gallipolis
Charleston
Buffalo
Niagara Falls
Toronto
Rochester
Canandaigua
Auburn
Newark
Mt. Morris
Dansville
Salamanca
Corning
Watertown
Burlington
Pittsburgh
Timberville
Harrisonburg
Petersburg
Courtland
Emporia
Portsmouth
Danville
Weldon
Elizabeth City
Tarboro
Wilson
Durham
Greensboro
Salisbury
Charlotte
Sanford
Goldsboro
Wilmington
Asheville
Greenville
Florence
Charleston
Toccoa
Gainesville
Chamblee
Atlanta
East Point
Jacksonville
Tampa
Miami

While attending the meetings of the National Plant Board at St. Louis, Mo., an opportunity was afforded to discuss with officials of various States, the Japanese beetle problem and how it was being dealt with. Outbreaks of this insect have been found at many points far removed from the main infested area. The results of these discussions were most encouraging. To cite some definite examples, the Japanese beetle was discovered in St. Louis, in 1934, when one thousand three hundred and fifty-one beetles were found. By soil treating and constant trapping, this number has been gradually reduced so that by 1941, only eighteen beetles were discovered. During this period, however, hundreds of acres of land have been treated and this past summer, a total of twelve thousand two hundred and forty traps were distributed over the entire city. In the Chicago area, the beetle was first discovered in 1935, when one thousand beetles were captured and the following year over four thousand. By 1937, however, less than ten beetles were found and in the treated areas no further discoveries have been made. Occasional outbreaks have been found outside the areas but these were dealt with promptly soon after the discovery. In 1941, approximately fifteen thousand traps were distributed in Chicago and the surrounding towns. In mid-summer of this year a heavy infestation was found on a large estate approximately thirty miles from Chicago. In all, over five thousand beetles were collected. Soil treating was started extending in every direction three hundred feet from where the last beetle was found. In all, seventy-eight and a half acres were treated. In the Detroit area, beetles were discovered ten years ago. This year, sixty-five additional acres were treated and although very extensive trapping operations were carried on, only two hundred and three beetles were found. In Indiana, the beetles were discovered at Indianapolis in 1934, and since that time infestations have been found at fourteen different points. The same policy has been carried out; soil treatment and extensive trapping. During this period, six of the infestations have been eliminated and in all others, with the exception of a new one discovered this year, the number of beetles captured has been very materially reduced. In reviewing the Indiana situation, the State entomologist, Mr. Frank N. Wallace, stated that by treating and trapping incipient outbreaks, the Japanese beetle can be held in check.

With regard to the Japanese beetle in eastern Canada, the success of the work depends upon the assistance and co-operation received from everyone including the general public. The first step is the prompt reporting of outbreaks not discovered by departmental inspectors in order that precautionary measures may be taken. It is proposed to extend trapping operations very materially along the north shore of the St. Lawrence River, adjacent to the United States boundary, especially at strategic points, increase trapping in the vicinity of railway yards and elsewhere where incipient outbreaks are likely to be found; and to treat incipient outbreaks when discovered.

EVIDENCES OF A SECOND GENERATION OF THE EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* HBN., IN ONTARIO*

By David A. Arnott

Dominion Entomological Laboratory, Chatham, Ontario

Since 1920, when the European corn borer was first discovered in Ontario, the occurrence of a second generation has been of little importance. For many years, the extent to which a second generation developed has apparently been negligible. The author has found very little data on the subject in published

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*Contribution No. 2140, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

articles on the corn borer in Ontario and the few unpublished data available pertain only to the southwestern portion of the province.

In the states of Ohio, Michigan and Indiana, immediately adjacent to southwestern Ontario, there evidently has been an increased development in recent years of the proportion of second generation borers. A. M. Vance (4), investigating the problem in these states, records that previous to 1936 the extent of second generation development was negligible. During 1936 and 1937, however, a significant increase occurred. In Indiana, in 1936, 5.7 per cent of the larval population in one district was second generation, and in 1937 in the same district, the proportion was 28.1 per cent. In an area near Toledo, Ohio, during 1936, the proportion of second generation borers was found to average 6.2 per cent of the population and in individual fields ranged from 1.3 to 24.0 per cent. During 1937, in the same area, second generation borers averaged 8.7 per cent of the population and in individual fields ranged from 2.8 to 17.6 per cent.

In Ontario, as early as 1921, H. G. Crawford and G. J. Spencer (2) found evidence of second generation development at Port Stanley, which involved but a fraction of one per cent of the borer population in that area. From 1921 to 1931, it appears that any occurrence of second generation development was insignificant, for, in 1931, L. Caesar and R. W. Thompson (1) state that though a small second generation does sometimes occur in a long warm season, much less than one per cent, it may safely be considered negligible.

During the period 1931 to 1941, definite evidence of second generation occurrence consisting of adult flight records was secured at Chatham, Ont. The author operated a light trap each season during this period and nightly records showed that long after the regular flight period had ended, adults were captured. G. M. Stirrett (3), investigating corn borer flight at Chatham during the period 1928 to 1936, considered the very late seasonal captures in the trap from 1931 to 1936 the only possible indication that a very small partial second generation occurs in some years in Ontario. His investigations showed that regular flight in the field ended by August 9. In the trap, moths were captured after August 23 and as late as October 26.

The accompaning table lists the date of capture and number of very late flying moths taken in the trap.

Further evidence available to the author consists of mid-summer pupation recorded in southwestern Ontario during 1940 and 1941. Through the courtesy of Mr. A. B. Baird, in charge of the Dominion Parasite Laboratory, Belleville, the author was provided with pupation data secured by Mr. G. Wishart of that laboratory during his corn borer investigations in Essex, Kent and Elgin counties. During the period August 21 to 24, in 1940, from Tecumseh to Leamington, along the shore in Essex county, midsummer pupation of borers indicated second generation development amounting to 3.5 per cent of the population. Of 1816 individuals examined, 64 had reached the pupal stage and by August 24, over 80 per cent had emerged as adults. The highest proportion of second generation individuals in this area was found at Oxley, being 13.0 per cent, all of which had emerged.

In 1941, second generation development was found in the same area of Essex county, at Chatham and Cedar Springs in Kent county, and at Port Stanley in Elgin county. In the Essex county area, during the period July 23 to 26, midsummer pupation indicated that 3.1 per cent of the population was second generation, the highest proportion being 16.0 per cent, again found at Oxley. In the Chatham and Cedar Springs area, second generation pupae comprised 3.5 per cent of the population and the same percentage was found at Port Stanley.

TABLE 1. RECORD OF SECOND GENERATION MOTHS OF *Pyrausta nubilalis* HBN., CAPTURED IN LIGHT TRAP, CHATHAM, ONTARIO, 1931-1941

Year	August				September												October					Total
	24	25	26	31	1	8	13	16	17	18	19	20	24	25	26	28	1	12	15	16	26	
1931				1					1													2
1932	1	2	1																			4
1933	None																					0
1934					1												1					2
1935		2											1									3
1936																				1	1	2
1937						2																2
1938																			1	2		3
1939								1					1			1						3
1940							2			2	4	3										11
1941								1							1			2				4

Officers of the Chatham laboratory, in 1941, found immature larvae, pupae and empty pupal cases during the period September 23 to 30, at Ridgetown, indicating second generation development which amounted to only 1.1 per cent of the population.

The evidences of second generation development in Ontario as presented in this paper indicate that the occurrence is probably confined to the southwestern part of the province. Light trap records at Chatham indicate that second generation development occurs during most seasons, but to a very small extent. Midsummer pupation as observed in field indicates that a considerable proportion of second generation borers developed in one locality during 1940 and 1941, but the average for any one area remained quite small, 3.5 per cent being the greatest.

The highest proportion of second generation development which occurred at Oxley, in Essex county, is of particular interest as this portion of the province is in close proximity to the area of increased occurrence in the states of Ohio, Michigan and Indiana. The question of whether second generation development in Essex county is tending to increase in recent years is one of biological interest. Before such a tendency can be fully determined further investigations and evidences are required.

References

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THE CORN BORER SITUATION IN ONTARIO IN 1941 WITH NOTES ON HYBRID AND BROOM CORN INFESTATION

By R. W. Thompson, *Ontario Agricultural College*

In 1941 the average percentage of stalks infested by corn borer, in the territory where clean-up regulations are in effect, was considerably reduced in comparison with 1940. While it was not possible to make counts in several of the counties comprising the above-mentioned territory, general observations which were made in such counties indicated similar conditions to those revealed by the actual field surveys made in the remainder of the area. In the husking corn counties of Essex, Kent, Lambton and Elgin the average stalk infestation was reduced to approximately half of that recorded for 1940. Even greater reductions occurred in the central Ontario counties where, in some cases, as can be seen in Table No. 1, not more than one-third or one-quarter of the percentage of stalks were infested in comparison with the previous season. It will be noted also that smaller reductions in infestation occurred in the Niagara Peninsula. In 1940, however, the infestation was lighter in this part of the province than in any other part of the territory where the clean-up regulations are enforced.

There seems to be no doubt that weather conditions are once more primarily responsible for the contrast in infestation which has occurred in 1941. Last season weather conditions were very favourable for the borer, especially during the late

TABLE NO. I

AVERAGE PERCENTAGE OF STALKS INFESTED BY CORN BORER

COUNTY	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941
Brant	10	**16**	15	10	....	7	15	15	....	3	4	19	....	25	**63**	25
Durham	....	**6**	....	21	12	11	....	....	9	17	15	18	27	....	49	....
Elgin	48	37	24	21	9	17	23	17	7	18	16	25	50	40	70	29
Essex	83	**65**	42	36	17	28	28	30	9	20	32	47	34	29	68	34
Haldimand	4	30	12	8	....	....	....	....	6	4	6	15	....	....	62	....
Halton	....	....	....	9	12	13	12	17	11	8	15	7	20	....	57	....
Hastings	....	....	....	10	27	13	....	....	....	....	25	13	....	....	....	....
Huron	11	17	12	16	....	....	....	28	....	14	....	16	....	....	46	19
Kent	70	49	35	21	22	27	29	35	6	24	20	44	42	34	73	34
Lambton	34	57	21	14	7	....	35	23	8	21	20	31	41	38	81	40
Lennox	.5	2	12	22	33	27	19	18	....	....	46	18	....	....	....	....
Lincoln	5	43	30	11	9	11	13	20	5	4	12	6	....	5	39	33
Middlesex	29	36	18	10	9	15	22	20	5	6	14	22	34	33	64	29
Norfolk	16	10	20	6	5	5	11	9	3	9	4	30	26	27	70	26
Northumberland	....	....	....	18	16	8	....	....	5	....	15	13	....	....	41	....
Ontario	....	....	....	9	4	5	....	....	15	17	23	19	21	....	50	....
Oxford	31	14	15	18	....	13	16	17	6	17	19	34	29	38	70	22
Peel	....	....	10	19	17	22	29	39	11	12	12	11	....	....	63	36
Pelee Island	....	....	15	24	5	6	7	12	4	9	13	22	13	17	26	....
Perth	....	8	9	16	....	....	....	6	....	12	....	20	....	45	64	25
Prince Edward	....	....	18	21	28	17	....	....	....	44	27	22	....	....	....	....
Waterloo	....	....	8	5	....	....	13	11	....	7	....	12	....	25	66	22
Welland	24	41	26	5	14	10	....	7	2	4	4	16	12	....	35	31
Wellington	....	....	....	8	5	....	9	....	....	7	10	3	....	....	65	26
Wentworth	....	22	25	9	13	8	17	19	8	6	7	12	17	21	39	28
York	....	....	....	....	....	5	22	....	....	16	8	28	....	....	68	26

spring and summer months. In 1941, in all parts of the province there were prolonged periods of dry weather particularly during June and July, the critical months in the life cycle of the borer. Rainfall in Essex and Kent counties was more frequent than in any other part of the territory where clean-up regulations are in force, although in these two counties there was less than the average amount of moisture.

In addition to the reduction brought about by weather conditions unfavourable for the borer, it should be noted that there was a much more determined effort on the part of corn growers to make a thorough clean-up of corn refuse of all kinds. This resulted from observations on the part of the growers of the increase in borer populations and damage which had occurred in a single season. Because of this attitude on the part of the growers it was easier for the inspectors to enforce clean-up regulations more strictly. From the standpoint of clean-up, therefore, it can be stated that a smaller amount of corn refuse was left undestroyed in the area of enforced clean-up than at any time since the inception of the Corn Borer Act.

It must not be assumed, however, from the above table and statements that no damage from corn borer occurred in 1941. Most of the loss was experienced in early table corn. The earliest table corn on the market appeared to escape serious injury, but in a number of districts the second picking of ears was quite

TABLE NO. II

AVERAGE NUMBER OF EUROPEAN CORN BORERS PER 10 STALKS IN STANDARD AND HYBRID CORN, GUELPH, 1938, 1939, 1940 & 1941

Variety or Strain	*Borers* 1938	1939	1940	1941	*Variety or Strain*	*Borers* 1938	1939	1940	1941
Golden Glow Stewart	23	28	74	39	Wisconsin 531	16	31	84	24
Wisconsin 355				38	Wisconsin 620	12	32	47	24
Richey 1 x 2				37	Richey 602 x 603				23
Longfellow	21	42	61	35	Wisconsin 696				23
Quebec x Lanc.			57	35	Wisconsin 525	18	35	67	22
Minhybrid 402	19	29	77	35	Kingscrost D		27	76	22
Harrow No. 27				33	Compton's Early	17	20	50	21
Harrow No. 82				31	Wisconsin No. 7	20	21	55	21
Excelsior	18	36	65	31	Richey 572 x 573				21
Golden Glow Cohoe	18	30	56	30	Wisconsin 625	11	30	47	21
Pioneer 353 LF				28	Funk's G 17		27	47	20
Pioneer 370 MF				28	Cornell 29 x 3	18	36	68	20
Minhybrid 301	15	31	68	27	Funk's G 12			64	20
Wisconsin 456		36		27	Wisconsin 570		25	52	20
Kingscrost M		25	66	27	Wisconsin 606	14	18	52	20
Ohio K 35	20	33	65	27	Ohio K 23			54	20
Stewart x (23 x 26)				27	Wisconsin 645	13	21	63	20
Funk's G 5			85	26	De Kalb 404A				19
Salzer's N. Dakota	15	42	56	26	Funk's G 15			74	19
Funk's G 6			86	26	Funk's G 7		19	63	18
Pioneer 358				26	Pioneer 355 MF				17
De Kalb 240				25	Minhybrid 401	23	30	72	16
Pioneer 324 LF				25	De Kalb 202	13	32	53	15
Kingscrost F.B.	10	24	48	24	Pioneer 322 LF				13
Kingscrost L.	11	32	58	24					

heavily infested and thus it was necessary to discard a considerable percentage of the crop. At the canning factories a big reduction in borer damage was noted during the 1941 packing season.

Damage to field corn was comparatively light in practically all of the area under enforced clean-up regulations. In addition to the less favourable weather this season it should also be noted that, especially in the husking corn area of western Ontario, there was a big increase in the use of hybrid corn seed. In Essex and Kent it is estimated that fully 80 per cent. of the corn acreage in 1941 was planted to hybrid corn. Such fields, even when heavily infested, showed little or no stalk breakage as was common previously in fields of open pollenated corn. From the results obtained this year with the strains of hybrid corn of recognized value it appears likely that a greater acreage still will be planted to hybrid corn in 1942.

In previous papers the performance of experimental strains of hybrid corn under plot conditions has been reported.* Counts of borer populations were limited this year to the Guelph plots. Table No. 2 shows the average number of borers found in the various strains of hybrids under tests at the Field Husbandry experimental plots at the College. This season forty-nine strains and varieties were tested, three replicates being examined. Where any of the strains were tested in previous years these are shown in Table No. 2. As in previous years some of the Wisconsin hybrid strains showed comparatively small borer populations although with the smaller stalk infestation which occurred throughout the province generally it is difficult to show the marked differences which have been demonstrable in some previous years. New strains are being introduced each year and it is therefore not possible to show the performance of all strains and open-pollenated varieties given in reports of previous years. The adoption of hybrid strains of corn by such a large percentage of the growers, is however, a fair indication of the results which are being obtained with new strains of hybrid corn which have resulted from attempts to produce borer resistant corn.

As a point of interest in connection with broom corn, infestation counts were made on small plots grown in experimental tests at Guelph. The four varieties counted in these observations are shown in Table No. 3. In the case of the White Italian broom corn it is interesting to note that stalk breakage, as a result of corn borer feeding, was quite noticeable at some distance from the plot.

This note is added because for several seasons there has been a misapprehension amongst some of the growers that broom corn is not susceptible to corn borer attack and as a result need not be cleaned up or destroyed in compliance with the regulations.

TABLE NO. III

CORN BORER INFESTATION IN BROOM CORN PLOTS 1941

Variety	Borers per 100 stalks
Early Black Spanish (85 - 90 day)	12
Early Bulgarian (90 - 95 day)	12
White Italian (95 - 100 day)	29
Late Hungarian (100 - 115 day)	15

*Annual Reports, Entomological Society of Ontario, 1938, 1909 and 1940.

THE WHITE GRUB SITUATION IN ONTARIO DURING 1941 AND A FORECAST FOR 1942*

By G. H. Hammond, *Division of Entomology, Ottawa.*

During 1941, as determined from extensive surveys and reports, white grubs and June beetles were a major pest of farm crops and shade and forest trees over a large part of agricultural Ontario. Two broods were responsible, brood A which was in the adult stage in 1941 was characterized by major flights and first year grubs and brood C which was in the adult stage in 1940 was present in the destructive second year grub stage and caused very important losses to farm, garden and nursery crops. Bearing in mind the three-year life cycle of broods A and C developments were similar in 1935 and 1938, as would be expected from the constant and uniform development of the two broods over a period of years. The capital letters indicating broods of contemporaneous development are those used by the United States Department of Agriculture. Hence broods "A" and "C" in the northern United States are similar in cyclic occurrence to the similarly designated broods in Ontario.

In the following summary for 1941 and forecast for 1942 the more important features of broods A and C are mentioned. In this summary we may consider that June beetle defoliation is not nearly so important as damage to plant roots from second year white grubs, hence the year of occurrence of the destructive second year grubs is of paramount importance.

Brood A

Brood A covers a part of the upper Ottawa valley in Quebec and a large part of agricultural Ontario. This brood is in general of great economic importance because of the large area involved and the intensity of its population from time to time. For 1940, the stages represented were third year grubs, pupae and dormant June beetles. The latter formed a major flight in 1941 which was accompanied by widespread and severe damage to thousands of deciduous forest and shade trees. Following this flight June beetle eggs occurred in enormous numbers in suitable habitats from which numerous young first instar white grubs hatched, principally in July. These grubs, although feeding from late July to late September, caused only minor damage to plant roots because of their comparatively small size but they will be a serious menace to a wide range of agricultural crops during 1942.

Brood A in significant infestation was present in five areas in Ontario; in eastern Ontario, central Ontario, about Lake Simcoe, Bruce county and in south-western Ontario. Generally speaking, the eastern Ontario area extended from Carleton and Grenville counties eastward to Glengarry, the central Ontario zone from Lanark to Peterborough, the Lake Simcoe infestation, the northern part of Ontario and York counties, all largely located on the south side of the lake, the Bruce county infestation covered mainly an area along Lake Huron for the length of the county and the south-western Ontario unit covered a large area of farm land between and including Middlesex to Wellington county, extending around but not overlapping with units of brood C.

Flights of the beetle in the eastern Ontario, Lake Simcoe and Bruce county areas indicated a light infestation throughout. That in eastern Ontario showed little change from 1938 but the other two units indicated a material drop in degree of severity of infestation; in all three, defoliation of food trees was of small proportions, and we may expect only light or at most moderate injury during 1942. Flights of the beetle in central Ontario, as between Lanark and Peterborough

*Contribution No. 2136, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

counties, were very conspicuous; thousands of ash, elm, hickory, oak, poplar, basswood, butternut and other trees were defoliated, a circumstance which interfered with seasonal growth. Counts of first year white grubs in meadow and pasture showed these insects often were present to the number of 100 or more per square yard, concentrations sufficient to cause very severe crop damage during 1942.

The south-western Ontario unit was characterized by a heavy flight of beetles which caused widespread partial defoliation to many species of trees, particularly ash, willow, poplar, oak, walnut and willow. This defoliation was particularly intense between Strathroy and London and between Brantford and Guelph and especially so between St. George and Galt over high pasture and meadow lands where hundreds of trees and shrubs were completely stripped.

Hence, in the areas in Ontario of heavy or severe June beetle flight during 1941 we may expect very important outbreaks of second year white grubs in 1942, namely in Lanark, Frontenac, Addington, Hastings, Peterborough, Wellington, Waterloo, Brant, Oxford, Perth and Middlesex counties.

Brood C

Brood C the typical brood of June beetles over southern and eastern Quebec and over the Lambton county, Niagara and Oshawa areas in Ontario, was the brood responsible for the more serious white grub injury in Ontario in 1941. White grubs which attacked crop roots in 1941 were from eggs deposited during 1940. Areas of infestation occur at three points in the Province, each separated from the other to some extent and each representing the Canadian element of the large brood C areas in New York and Michigan.

No important damage from the small first year grubs occurred during 1940 but severe damage occurred in the Oshawa, Niagara and Lambton units of this brood this year. In the Oshawa district a severe, generalized outbreak occurred in the Markham-Uxbridge-Brooklin triangle; in the Niagara peninsula a general outbreak occurred which reached a peak between Welland and Dunnville and caused much damage to many crops in the area. The Lambton county outbreak of brood C which was discovered by Dr. Geo. M. Stirrett of the Chatham, Ontario Entomological Laboratory, was found to cover an irregular area in Lambton county, with offshoots extending into adjoining counties. The centre of this outbreak was located near Cairo in the south-east corner of Lambton county and, while sod, potatoes, corn and some other crops suffered important injuries, the most unusual and spectacular attack was on sugar beets, many fields of which were seriously damaged.

Species responsible for the damage to crops were *Phyllophaga anxia* Lec. and *P. fusca* Froe. in the Oshawa-Uxbridge area, *P. rugosa* Melsh., *P. fusca* Froe., *P. inversa* Horn, *P. anxia* Lec. and *P. futilis* Lec. in the Niagara peninsula; *P. rugosa* Melsh., *P. fusca* Froe., *P. futilis* Lec. and *P. anxia* Lec. in the Lambton county unit.

The 1942 Situation

For 1942 we may have little concern from the standpoint of direct loss from white grubs in the brood C zones. Indirect damage from this brood in the form of establishment of weeds, pasture plant dilution, or soil erosion, may be reduced by ploughing and reseeding seriously-damaged areas with exceptionally-thorough soil preparation. Establishment of new alfalfa may be undertaken with little fear of important injury to the young seedlings. Re-seeding or replacement of sod in lawns and golf courses may also be necessary.

In the areas where brood A is prevalent, exceptional precautions will be necessary to prevent serious losses from the ravenous second year grub stages

which will be feeding from May to September. The ideal time for the treatment of old sod intended for hoed crop in 1942 was August 1941 but the shallow-plough-ing-multiple-discing treatment may be applied with good effect after grubs have risen to the surface soil in May.

Adequate crop fertility will reduce actual injury from white grubs and will hasten recovery after injury.

Applications of arsenate of lead to protect permanent sod or valuable plants should be made relatively early in the 1942 season and watered at the time of treatment to assist the poison to penetrate into the soil.

THE PROGRESS OF THE POTATO APHID SURVEY IN NEW BRUNSWICK AND ADJACENT PROVINCES*

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In the 65th report of the Ontario Entomological Society, 1934, a brief summary was given of the work accomplished in the first year of the survey. In the 70th report, 1939, a further progress report was made under the above title. Following is a summary of the work done in 1940 and 1941.

As in previous years the entomologists and potato inspectors in Prince Edward Island, Nova Scotia and eastern Quebec collaborated in making and forwarding collections and to them thanks are extended. The collections in New Brunswick and Nova Scotia in 1941 were made by the laboratory staff. Daily reports were sent to the chief potato inspectors and collaborating officers in each province so they might be kept informed concerning the species of aphids present on the potato foliage in the respective districts of the provinces. These reports were issued within eight hours after receipt of samples.

In 1940 samples were received from 182 farm fields in New Brunswick, 290 in Prince Edward Island, 37 in Nova Scotia, and 99 in eastern Quebec.

In 1941 samples were received from 123 farms in New Brunswick, 157 in Prince Edward Island, 10 in Nova Scotia, and 68 in eastern Quebec.

The smaller number of samples collected in 1941 was due to an effort to collect chiefly from selected representative points instead of from many fields in each commercial potato growing district. Whenever possible four samples were obtained from each field.

Following is a summary of the records for the years 1940 and 1941, noting the number of field collections in each province, the number of field collections and the number of field samples in which each species was found.

New Brunswick

			1940	1941
Field Collections			182	123
Species	No. of fields in which present 1940	1941	No. of Samples in which present 1940	1941
M. solanifolii Ash.	172	81	564	123
M. persicae Sul.	133	102	313	181
A. abbreviata Patch	62	48	88	83
M. pseudosolani Theo.	8	3	58	6

*Contribution No. 2128, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

PRINCE EDWARD ISLAND

	1940	1941
Field Collections	290	157

Species	No. of fields in which present 1940	1941	No. of Samples in which present 1940	1941
M. solanifolii Ash.	286	81	658	559
M. persicae Sul.	181	102	209	282
A. abbreviata Patch	40	48	68	141
M. pseudosolani Theo.	11	3	16	7

NOVA SCOTIA

	1940	1941
Field Collections	37	10

Species	No. of fields in which present 1940	1941	No. of Samples in which present 1940	1941
M. solanifolii Ash.	37	10	145	29
M. persicae Sul.	11	8	30	19
A. abbreviata Patch	2	0	3	0
M. pseudosolani Theo.	2	0	3	0

EASTERN QUEBEC

	1940	1941
Field Collections	99	68

Species	No. of fields in which present 1940	1941	No. of Samples in which present 1940	1941
M. solanifolii Ash.	95	54	255	198
M. persicae Sul.	46	50	47	145
A. abbreviata Patch	15	36	14	69
M. pseudosolani Theo.	14	3	14	4

In the province of New Brunswick *Macrosiphum solanifolii* Ashmead was less abundant than in 1940. While it could be found in every field it was not numerous anywhere. In the province of Prince Edward Island and in the eastern portion of the province of Quebec quite severe infestations of this species developed late in August.

Myzus persicae Sulzer and *Aphis abbreviata* Patch were the most common species of aphids present on the potato plants in New Brunswick. This was true also of portions of Prince Edward Island and portions of eastern Quebec. In some instances both species were abundant in the same districts, in other instances one species alone was abundant in a particular region. By making use of the survey records obtained in previous years and correlating these with the field study it was found that these local infestations bore a distinct relationship to the proximity of winter host plants as the source of the primary spring infestation. The direction of the dispersal flights from the primary spring host plants to secondary host plants was of importance in connection with the late August infestations.

From the beginning of the survey in 1934, constant search was made for the winter host plant of *Myzus persicae* Sulzer. In the autumn of 1940, oviparous females were found on wild plum, *Prunus nigra* Ait. Branches bearing eggs were brought indoors in April of 1941 and *Myzus persicae* hatched out and found to colonize readily upon potato sprouts. Search was at once made for colonies on wild plum. These were found on May 26 and it was proved by trial that they would colonize on potato. At that time it was believed that wild plum was not a

common shrub in New Brunswick but a rapid survey made in the early part of June showed that it was present in small clumps on many farms in the counties of York, Carleton, Madawaska and Northumberland.

The aphid survey maps of previous years showed that the places where the wild plum was found to be abundant were also the places where *Myzus persicae* Sulzer had been taken early in the season in past years.

The development of winged migrants on the plum was first noted on June 3 before many potato plants were above the soil surface. These first migrants were found to colonize upon Swedish turnip and wild radish plants close to the plum thickets. The presence of winged migrants and nymphs on potato plants near plum thickets was noted on June 16. By the 19th of June several nymphs could be found on every potato plant. Field observation on the 16th, 17th, 18th and 19th, showed that the winged migrant aphids instead of settling to form colonies depositied one nymph in a place and moved on to another plant. This observation gave the explanation concerning the manner in which the large number of potato plants in a field became aphid-infested at or near the same time.

Cabbage, beets, Swedish turnips and wild radish were found to receive aphid nymphs at the same time as the potato so it was clear that from the winter host plant the winged migrants spread to a number of primary spring host plants including some of the most common cultivated farm plants.

The dispersal flight from the primary spring host plants began in the first part of July, pupae and the first winged adult being found on potato July 10. This dispersal flight resulted in the infestation of late planted potato plants which had not been above the soil surface in the first three weeks of June and also of the wild radish plants in grain fields near plum thickets.

A second and mass dispersal flight took place in the middle of August. This mass flight had been observed in 1939 and 1940 as is noted in the Canadian Entomologist, September, 1941. Flight traps were set up at a number of places in anticipation of this flight and large numbers of both *Myzus persicae* and *M. solanifolii* were captured in the period August 16-20. This flight resulted in the infestation of potato fields in certain districts where there were no plum trees and where the plants had been free from infestation by *Myzus persicae* in the early part of August.

A third mass dispersal flight developed in early September when potato foliage was beginning to die. The winged aphids leaving the potato moved to a great many different plants. Many of these aphids were affected by a fungus disease and died but some reared young. A comparatively small number were found on plum late in October and these developed oviparous females to deposit eggs.

The most severe infestations of *Aphis abbreviata* Patch were generally localized within a comparatively short distance of the winter host plant. This host plant was one of the three species of buckthorn known to grow in New Brunswick. Two of these, *Rhamnus cathartica* L. and *Rhamnus frangula* L., are of European origin. The third, *Rhamnus alnifolia* L'Hebert is a Canadian plant which grows in swamps and damp pasture land. The eggs of this species were found hatching on May 1. The flight of the winged migrants to potato and wild radish and a variety of other primary spring host plants took place in early June. The return flight from the potato to buckthorn was direct and began in the second week of September. Large numbers of eggs were deposited before the end of September on *Rhamnus alnifolia*. On *Rhamnus cathartica* L. and *Rhamnus frangula* L. the oviposition period extended well into October.

A TIMING EXPERIMENT WITH COMBINATIONS OF MERCURY INSECTICIDES USED FOR THE CONTROL OF THE ONION MAGGOT*

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For the past few years, the majority of the insecticides used for the control of the onion maggot have been tested in field plot experiments at Ottawa, and in the course of these tests it was noticed that one, the calomel seed treatment suggested by Glasgow (1929), was particularly effective in checking the initial maggot attack. Its effectiveness lessened rapidly, however, as the season progressed. In light infestations, the seed treatment gave a satisfactory degree of control; in medium or heavy infestations, better results were secured with an oil emulsion spray, mercury bichloride solution or the 4 per cent calomel dust recently recommended by Wright (1939). With the three latter insecticides, 2 to 4 applications were required. Since only one application was necessary with the seed treatment, labour and cost of materials were reduced to a minimum. Further, the seed might be coated with the poison some weeks in advance of planting—before the pressure of early spring work. Obviously, the seed treatment had advantages, and while not completely effective in itself, it might have value when used in combination with certain other insecticides. The control experiment programs of 1940 and 1941 were designed on the basis of this possibility.

1940 Experiment. In 1940 certain plots where the seed had been coated with calomel a day or two before planting, received supplementary treatments of 4 per cent calomel dust, mercury bichloride solution or oil emulsion spray; in other plots where the seed had not been treated, these insecticides were applied according to the recommended schedule. The results with the combination treatments were encouraging—in all cases, the latter treatments were considerably more effective than the single treatments. For example, where the control secured with the calomel seed treatment was 49 per cent and where the control with the 4 per cent calomel dust was 66 per cent, the control was increased to 93 per cent through the use of the combination. Similarly, where an oil emulsion spray was used alone, the control was 43 per cent; where the spray followed the seed treatment, the control was 73 per cent. These results were obtained in an infestation which probably was of average severity, since 36 per cent of the seedlings in the untreated check plots were killed by maggot.

1941 Experiment. The 1941 study of the combination treatments consisted of a single "timing" experiment with calomel seed treatment plus mercury bichloride solution and calomel seed treatment plus 4 per cent calomel dust, conducted according to a modification of the plan suggested by Glasgow (1940). The object of the study was to determine (a) whether the applications of the supplementary treatments might be reduced in number, and (b) the correct timing of the supplementary treatments. A description of the 1941 experiment follows in detail.

In both years' control studies, the combination treatments were tested on small plots of onions grown from seed in a one-fifth-acre range of sandy loam. Eighty-five plots were set out in the 1941 experiment, and each plot consisted of two adjacent rows 30 feet in length. As indicated in Table I, 19 treatments or schedules were tested in quadruplicate while the remaining 9 plots were allotted to the twentieth or check treatment. The efficiency of the treatments was judged by the percentage of seedlings killed by maggot throughout the season, and for

*Contribution No. 2131, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

this purpose 7 weekly or semi-weekly records of the wilted plants were taken from May 30 to July 4. One-half the onions in each plot were sampled at each inspection. When wilting of the onions from maggot attack practically had ceased, a single count of the living onions was made during the period of July 9-14. In Table I, the total number of dead onions recorded on the seven dates of inspection has been expressed as a percentage of the sum of the dead and living onions in the sample plots on July 14.

The calomel dust used in both years' tests was prepared by a commercial firm and consisted of 4 per cent calomel in a clay carrier. The dust was applied with a cheesecloth bag, in a continuous narrow strip along the rows of onions, at the rate of 6 ounces per 60-foot plot, and there were from 1 to 3 applications. The first was made on May 16 when the majority of the seedlings still were in the "loop" stage, while the second and third followed at 10-day intervals. The mercury bichloride solution, poured along the rows from enamelled pitchers, was used at a dilution of 1-1600 and at the rate of ¾ gallons per 60-foot plot. There were from 1 to 4 weekly applications of this material on May 16, 23, 30 and June 6. In the

TABLE NO. I.

RESULTS WITH COMBINATIONS OF MERCURY INSECTICIDES USED FOR THE CONTROL OF THE ONION MAGGOT, OTTAWA, ONTARIO, 1941.

Treatment	Timing & number of applications				Onion seedlings				Per cent control
	1st.	2nd.	3rd.	4th.	Number observed	Number alive	Number dead	Per cent dead	
1. C.S.T.—C.D.	x	x	–		4350	4164	186	4.3	92
2. C.S.T.—C.D.	x	x	x		3857	3647	210	5.4	90
3. C.S.T.—M.B.	x	x	x	x	3947	3735	214	5.4	90
4. C.S.T.—M.B.	–	x	x	x	4145	3837	308	7.4	87
5. C.S.T.—M.B.	x	x	x	–	4056	3726	330	8.1	85
6. C.S.T.—M.B.	–	x	x	–	4819	4407	412	8.5	85
7. C.S.T.—C.D.	–	x	x		4774	4180	594	12.4	78
8. C.S.T.—M.B.	x	x	–	–	4359	3769	590	13.5	76
9. C.D.	x	x	–		3927	3363	564	14.4	74
10. C.S.T.—C.D.	x	–	–		4325	3690	635	14.7	72
11. C.S.T.—M.B.	–	x	–	–	4324	3615	709	16.4	71
12. M.B.	x	x	x	x	3651	3016	635	17.4	69
13. C.S.T.—C.D.	–	x	–		4136	3339	797	19.3	65
14. C.S.T.—M.B.	–	–	x	–	4108	3063	1045	25.4	54
15. C.S.T.—M.B.	x	–	–	–	3398	2463	935	27.5	51
16. C.S.T.—M.B.	–	–	x	x	4045	2899	1146	28.3	49
17. C.S.T.—C.D.	–	–	x		3898	2666	1232	31.6	43
18. C.S.T.—M.B.	–	–	–	x	4277	2636	1641	38.4	31
19. C.S.T.					3916	2225	1691	43.2	23
20. Check*					8831	3890	4941	55.9	....

* 9 plots. Others in quadruplicate.

case of the calomel seed treatment, the onion seed was moistened with a solution of gum acacia and then thoroughly coated with a quantity of pure calomel equivalent to the original weight of the seed. Seeding of the experimental bed took place on April 29.

In Tables I and II, the symbols *C. S. T.* represent calomel seed treatment, *M. B.* represents mercury bichloride solution and *C. D.* represents 4 per cent calomel dust. The percentage of control has been calculated by Abbott's formula (1925).

Results: Four applications of mercury bichloride solution at weekly intervals, and 2 applications of 4 per cent calomel dust at 10-day intervals were accepted as standard recommendations for onion maggot control. Where these treatments were applied as supplements to the calomel seed treatment, the combinations so formed were considerably more effective than the recommended treatments alone. (Compare treatments 1 and 9 and treatments 3 and 12 in Table I.) Where the calomel dust and mercury bichloride were used as supplements to the seed treatment, with *fewer* than the recommended number of applications, certain of the

TABLE NO. II.

COST PER ACRE OF CERTAIN TREATMENTS TESTED IN ONION MAGGOT CONTROL AT OTTAWA IN 1941, BASED ON PRE-WAR PRICES OF MATERIALS AND LABOUR.

Treatment	Timing and number of applications 1st.	2nd.	3rd.	4th.	Per cent control*	Cost per acre**
1. C.S.T.					23	$ 8.00
2. C.S.T.—M.B.	–	x	–	–	71	18.00
3. C.S.T.—M.B.	–	x	x	–	85	28.00
4. C.S.T.—M.B.	–	x	x	x	87	37.00
5. M.B.	x	x	x	x	69	39.00
6. C.S.T.—C.D.	x	–			72	42.00
7. C.S.T.—M.B.	x	x	x	x	90	47.00
8. C.D.	x	x			74	68.00
9. C.S.T.—C.D.	x	x			92	76.00
10. Check					....	

*Calculated by Abbott's formula (1925).
**Based on calomel and mercury bichloride at $2.50 per pound; clay dust at 3 cents; labour at 25 cents an hour; onion seed sown at 3 pounds to the acre with rows 14 inches apart.

resulting combinations were equal or superior to the recommended treatments alone. For example, treatment 6 (calomel-treated seed and 2 applications of mercury bichloride solution) was more effective than treatment 12 (4 applications of mercury bichloride solution). Similarly, treatment 10 (calomel-treated seed and 1 application of 4 per cent calomel dust) was the equal of treatment 9 (2 applications of 4 per cent calomel dust). The effectiveness of the combinations, of course, varied with the timing of the supplementary treatments; the 1941 results indicate that the most effective timing was the seedling "loop" stage with the calomel dust (compare treatments 10, 13 and 17) and slightly later with the mercury bichloride solution. (Compare treatments 6, 8 and 16).

Cost. The comparative costs of certain of the treatments, based on 1939 prices for materials and labour, have been indicated in Table II. These figures would suggest that the combined treatments might be used profitably by the grower; however, since in 1941 the retail price of calomel and mercury bichloride had risen to $5.00 a pound, the cost of these insecticides probably would prohibit their use in onion maggot control at Ottawa for the duration of the war.

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THE TOLERANCE OF LARVAE OF THE TOBACCO MOTH, *PHLEGETHONTIUS QUINQUEMACULATA* HAW., TO NICOTINE*

By GEOFFREY BEALL

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In the course of laboratory studies on insecticides, tests were made of the toxicity by ingestion and by contact of nicotine to larvae of *Phlegethontius quinquemaculata* Haw., which infests growing tobacco. Such sensitivity as this insect shows to nicotine may be worthy of record, particularly since the sensitivity is of an unusual nature.

The larvae used experimentally had been collected from the field soon after they hatched and been brought, in the laboratory, to the third day of their fourth instar, when they were about 1¼ inches long. At that time the experimental treatment either of the larvae or of their food was started. During the experimental period, the larvae were kept in copper screen containers (3¼ inches in diameter and 5¾ inches deep) with pieces (4 inches by 5 inches) or green tobacco (Burley) leaf which was replaced each day. The containers were used initially to hold 1 to 4 larvae, on 2 pieces of leaf, but as the worms grew they were dispersed over more containers, each of which held more pieces of leaf, so that in its latter days each larva, then about 3¼ inches long, was alone in a container with 4 pieces of leaf.

In one test the larvae were given a diet of free nicotine. A mixture of commercial nicotine sold as 40 per cent was diluted to some extent with distilled water and then swabbed on the lower surface of the pieces of leaf; excess liquid was shaken off, leaving about .4cc. on a piece of leaf; then the leaf was laid down for some 90 minutes to dry. At the end of that time, solutions as high as 10 per cent of nicotine were adsorbed or absorbed by the leaf which felt dry but which smelled strong. Generally the larvae were not embarrassed by the nicotine on the leaves as may be seen by the results, as follow: 14 larvae fed on leaves coated with 2.5 per cent nicotine all reached the prepupal state; of 27 larvae fed leaves coated with 5 per cent nicotine, 24 arrived at the prepupal state and of the dead, one was probably diseased and one possibly parasitized; 9 larvae fed leaves coated with 10 per cent nicotine all reached the prepupal state. The prepupae appeared in every way to be in good condition. Two reactions to the heavy diet of nicotine were noticed. First, there appeared a slight preliminary disinclination to eat the leaves, although the larvae soon settled down to feeding and continued to do so with that avidity characteristic of their species. Secondly, the faeces became jet black, even those freshly passed; this observation, of course, suggests that nicotine passed through the gut. It was impossible to carry the application of nicotine beyond the point of 10 per cent since then the resulting coating of the leaf remained sticky and the worms appeared to suffer from contact effects.

In the second test, the larvae were subjected once to contact with nicotine and were thereafter untreated and fed on untreated leaves. The larvae were submerged for one minute in various concentrations of nicotine, and then put on blotting paper for a moment, so that surplus liquid would drain off. The larvae were observed, if they lived, until they reached the prepupal stage, when they are

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shown in the following table as having matured, otherwise they are shown as having died short of maturity; the count was as follows:

Per cent Nicotine	2.5	5	10	20	40
Number matured	4	4	11	2	4
Number died	0	5	5	18	14

Most of the larvae were limp when they were removed from the nicotine; indeed, many of those which died from the treatment never recovered from this conditioh, although some lived for several days in a paralyzed condition. Other larvae which had remained or again became active seemed generally to have some difficulty in sloughing. In particular, they had difficulty in freeing the posterior part of the body; sometimes they freed only the head. In other cases, belts of dead skin remained about the body which was otherwise freed in a satisfactory way. Some larvae of the latter class apparently rid themselves of the belts ultimately and survived. While the paralyzed larvae showed that nervous derangement so commonly reported as a result on insects of nicotine, the larvae that were only injured superficially showed an affect which appears not to have been reported previously; possibly the latter group was damaged by the caustic effect of nicotine rather than affected nervously. Larvae that successfully negotiated the slough, after contact with nicotine, grew into large and apparently normal and healthy prepupae.

OBSERVATIONS ON THE RISE IN TEMPERATURE DUE TO METABOLISM IN CULTURES OF THE MEDITERRANEAN FLOUR MOTH, *EPHESTIA KUEHNIELLA* ZELL.*

By Geo. Wishart

Dominion Parasite Laboratory, Belleville, Ontario

A considerable amount of work has been done on the effect of temperature on *Ephestia kuhniella* Zell.; particularly in its effect on fertility. Norris, 1933, states that at 30°C. almost complete infertility of males occurs and that at 27°C. a high percentage of males are infertile. Raichoudhury, 1936, states that there is considerable retardation of spermatogenesis at 30°C. The material used in the experiments by the above workers was drawn from cultures held in chambers at the temperatures cited. None of the papers consulted indicated that cognizance had been taken of any increase in temperature, which may have occurred within the culture itself, due to the metabolic activity of the insects. Some of our work appears to indicate that this rise of temperature due to metabolism occurs at the time when the male gonads are being formed, and that it is of sufficient proportion to leave some of the statements in the literature open to question.

In order to determine what rise in temperature was produced in cultures of *Ephestia*, a series of tests was run. To contain the culture medium, and test insects, cardboard boxes 6″ x 6″ x 1″ deep were used. One hundred and twenty grams of whole wheat flour was spread evenly over the bottom of each box, making a layer approximately one-half inch deep. *Ephestia* eggs in the desired numbers were placed on top of the flour. A thermocouple junction was placed in the centre of each box slightly below the surface of the medium. Temperature readings were

*Contribution No. 2134, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

taken daily. As is well known, feeding by *Ephestia* occurs only in a thin layer at the top of the medium. No insect could, therefore, be more than one-half inch away from the top or bottom of the box, and not more than one-quarter inch away from the top or bottom surface of the flour. There was, therefore, ample opportunity for radiation of heat from the culture. The cabinet in which the boxes were kept was operated at 23°C. The check, containing no eggs, showed the same temperature as the cabinet throughout the experiment.

The accompanying chart shows the number of eggs used and the daily temperature readings above that of the check. As would be expected, the amount of rise in temperature in the culture is related to the density of the culture. However, even in the 750 egg culture, which would not be considered crowded, there was a rise during the fifth instar of 1.6°C. The greatest rise in temperature was 5.7°C. in the 3,000 egg culture on the 28th day. The greatest amount of heat is produced during the growth periods between moults, particularly in later instars where the actual bulk of the insects is greatest. This also corresponds roughly to the period during which the male gonads are formed.

It would appear, therefore, that data on the influence of temperature on fertility of *Ephestia* are only valid when the test insects were reared singly or in very sparse cultures.

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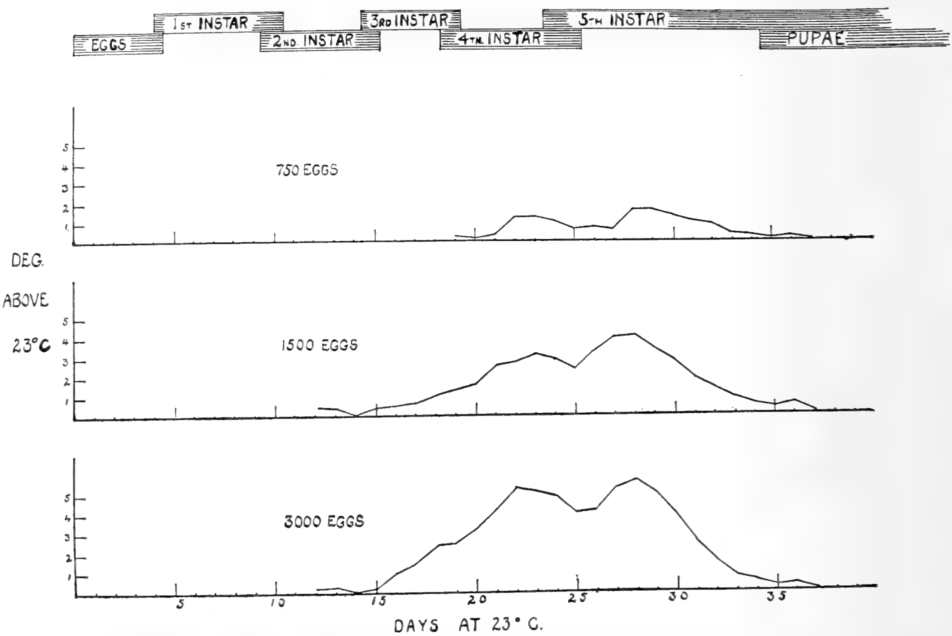

Graph showing degrees Centigrade rise in temperature above that of environment due to heat of metabolism in cultures of *Ephestia kuhniella* Zell.

SCOUTING FOR THE EUROPEAN EARWIG, *FORFICULA AURICULARIA* L. IN ONTARIO, 1938 TO 1941*

By CYRIL COPELAND *and* C. R. MESSER,

Plant Protection Division, Toronto.

The European earwig, *Forficula auricularia* L., was brought to the attention of Professor Caesar, then Provincial Entomologist, in the summer of 1938 by the son of a local storekeeper in Ayton. The outbreak was later called to the attention of the Dominion Department of Agriculture and representatives of the Divisions of Entomology and Plant Protection together with officials from the Ontario Department of Agriculture proceeded to Ayton to look into the matter. Owing to the lateness of the discovery, however, no further action was taken that year.

In July, 1939, arrangements were made to carry on scouting in an endeavour to determine the extent and distribution of the insect. In all, five days were spent in this work. Local residents were interviewed, especially those who had experienced trouble with the insect the previous year and from these much valuable information was obtained. The residents of the Ayton area were perturbed by the prevalence of the insect and certain of them were familiar with its habits in Europe. Stories were circulated, unauthentic of course, that earwigs would enter a child's ear and such stories caused considerable anxiety among certain people.

The hiding places of the insect are extremely varied. They were readily collected from the tassels or from the axil of the leaf in corn. They were found in cracks and crevices in posts, under stones, in bags and in clothing. They were even found inside the wrapping of a loaf of bread delivered to a house some distance from Ayton. They were reported as crawling into showcases in the stores and even into a box of straws at a soda fountain. They were frequently found in in corrugated paper boxes hiding in the corrugations and on one occasion in the turned-up cuff of a man's trousers. Earwigs were reported by residents as collecting in numbers around the tops of milk or cream cans; also around bags of grain and in or under old bags at chopping and flour mills. Evidence was obtained which seemed to indicate they had been carried to two outlying areas in sheaves of grain. These had been moved from Ayton and thrashed at farms some distance away.

The above instances which are by no means complete convey some idea of the ways in which the insect may be spread. A suggestion has been made that the insect may have been brought from British Columbia in bundles of shingles and while these seem to provide a favourable hiding place, it would appear that if such were the case, the earwig should have been found in a great many other districts and not only in such areas as Ayton where most of the shingles are of local origin. The possibility of the insect being brought into this area by ships entering at lake ports was given consideration, but after investigation, it was apparent that no freight of foreign origin was unloaded at these points. Scouting was carried on but no sign of infestation was found. How the insect first arrived in the Ayton area will remain largely a matter of speculation as it is unlikely to be established with any degree of certainty.

In 1938, the only outbreak discovered was in the Village of Ayton. The following year, twenty new infestations were found. These covered a large proportion of Normanby township extending nearly two and a half miles south-east

*Contribution No. 25, Plant Protection Division, Department of Agriculture, Ottawa.

and six miles northwest of Ayton. The infestation at Neustadt was of sufficient size to leave some doubt as to whether this was an original infestation or just the result of spread. All infestations in this area, both at Ayton and Neustadt were found within a mile and a half of the Saugeen River, and these occurred both east and west of the river, but were heavier on the east side.

In view of the discovery of the earwig in Grey county, it appeared possible that the whole north-western area of Old Ontario might be infested and further time was spent in scouting this area. Collingwood, Thornbury, Meaford, Owen Sound, Wiarton, Southampton, Port Elgin, Kincardine, Walkerton, Hanover, Elmwood, Chesley, Durham, Mount Forest, Mildmay, Clifford, Harriston and Palmerston were scouted but as no earwigs were found it may be safe to assume that there are no general infestations in these districts at the present time. However, there is a possibility of local isolated outbreaks in these districts, which have not been found on account of the limited time available for scouting.

In 1940, three days were spent in scouting. Traps borrowed from the Dominion Parasite Laboratory, Belleville, were used. These helped considerably in the work. Eight new infestations were found all in the area known to be generally infested in 1939 and extended the width of the infested area some distance both at the north and south limits. The infestation was also found to have extended into Bruce county on the north west, but there did not appear to be any general spread from farm to farm.

In 1941, the area was again visited and seven days were spent in scouting. A larger number of traps were used and these proved to be very helpful. Ten new infestations were found; one at Hanover about five miles north of the previous discoveries, and one at Durham seven miles north-east of any known outbreak. Walkerton, Hanover, Durham, Holstein, Mount Forest, Clifford, Mildmay and the areas around the old infestation were visited, but no outbreaks were discovered.

In summarizing this work, it is felt that although the extent of infestation may be greater than is known at the present time, it appears unlikely that there is any generally infested area outside the present zones. Isolated outbreaks may be started by a few earwigs carried long distances and it is not unreasonable to assume that the insect will be found from time to time in unexpected places. It is known to have been present in the Ayton and Neustadt districts for a number of years and must have become fairly abundant before being reported.

The infestation in Ayton has been reduced since baiting operations were carried out during the past three years by the Ontario Department of Agriculture and local residents are not nearly as interested in the earwig problem as they were in 1939. Although the insects are still present in numbers in Ayton, there has been less trouble with them entering houses.

One case of reduction worthy of mention was noticed on the farm of Mr. Ed. Plantz, at Neustadt, which in 1939 was among the heavily infested properties, whereas in 1941, only ten insects were collected in six traps and the earwigs were hard to find in their usual hiding places. Insects were found, however, at five new locations in the immediate vicinity. No explanation can be offered for the reduction in numbers, but no baiting operations were carried out. From the work that has been carried on, infestations appear to be found on rather open gravelly soil in comparatively rolling country. Up to the present time only two insects have been found at Durham, but conditions appear to be favorable for development of the pest and it will not be surprising if a marked increase occurs in the near future. In the Durham area, there is a large unused gravel pit covering a considerable

acreage on one edge of the town and the town itself contains many old buildings which might serve as ideal hiding places.

Up to the present time, earwigs have done very little damage to crops with the possible exception to cabbage in which they hide and leave slimy trails between the leaves, thus making the entire head unfit for human consumption. They have also been observed eating the tops of carrots. Fortunately, this area does not produce any large quantity of truck crops and about the only carload lots shipped out of the district are livestock which do not readily lend themselves to the distribution of earwigs. The present infestation is largely bordered on the east by a swamp-like area which may retard the spread of the insect in that direction. It would appear that over-wintering of the insect is dependent on some additional protection, since practically all the infestations found thus far have been in close proximity to buildings. This statement may be open to question, however, since reliable reports received indicate that the insects have been found in large numbers in stooked grain on remote sections of various farms.

NOTE ON MUNICIPAL BAITING CAMPAIGN AGAINST THE EUROPEAN EARWIG, *FORFICULA AURICULARIA*, AT AYTON, ONTARIO

By A. G. McNALLY, *Guelph, Ont.*

As reported before, (1) an experimental village-wide baiting was carried on at Ayton, Ontario, in 1939.

In 1940 the infestation was relatively light and no baiting was carried on.

Early in the summer of 1941 a search indicated another heavy infestation. Upon recommendation the citizens agreed to finance a municipal baiting campaign. The village was baited on July 4th and again on July 17th. Despite cool weather after the first baiting and light rain after the second, good practical control was obtained.

An interesting contrast was noted in the nearby village of Neustadt where no baiting was carried on. Here an early search indicated and earwig population comparable to that at Ayton. By midsummer when all the earwigs had appeared, the heavy infestation at Neustadt contrasted strikingly with the very light infestation following the baiting at Ayton.

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(1) A Test of Sodium Fluoride Bait in the Control of the European Earwig in Ontario, Ent. Soc. Annual Report 1939.

THERMAL PREFERENCE BY PHARAOH'S ANT, *MONOMORIUM PHARAONIS* (L.), AS A GUIDE IN CONTROL WORK.*

By J. E. Armand

Plant Protection Division, Toronto

Last year, while watching control operations being carried out by a commercial insect exterminator, an opportunity was granted to note some of the interesting habits of Pharaoh's ant and this insect's preference for a certain range of temperature. While the marching habits of the insect, the importance of trying to locate the nests, and the application of certain poisons are known, the observing of a thermal preference will apparently clear up mysteries, up to the present time not understood, and serve as a guide for more effective control.

The commercial exterminator had appealed to the Department for assistance in eradicating this particular outbreak in view of the fact that several other exterminators had attempted to control the infestation without success. The outbreak occurred in a two-storey building consisting of apartments and stores, with separate basements.

Inquiries of tenants resulted in conflicting answers being given regarding the preference of this ant for certain types of food, its habits, and prevalence at different seasons. The different statements with regard to food preferences were cleared by noting that the tenants stored the food in various ways, and this also explained the variation in the habits of the insects, as certain tenants stored no foods and, therefore, did not observe any regular trails to and from a supply of food. This, however, did not explain the mystery of the prevalence or absence of the ants at different seasons of the year. As an example: at a drug store at the corner of the building, the insects were reported as abundant in the summer and absent in cold weather; whereas at a hat shop at an extreme end of one wing of the building, winter abundance only occurred. Midway between these two stores there is a tailor shop where the insect was reported as being abundant throughout the year. A number of other instances might also be cited.

In the hat shop a trail was followed with a pencil and found to be clear cut and without deviation. This followed a perpendicular hot water pipe within the wall which warmed the plaster. The insects were found to follow the warm area but not in the centre directly over the pipe where it was very warm; it was rather to one side where the temperature was more moderate. The trail proceeded in a vertical line from the baseboard to a hole in the plaster near the ceiling and had just one branch to a nearby sink which some ants visited briefly.

In the basement of the tailor shop there was a vertical trail on a brick wall on one side of a warm area. On the other side of this same wall, in the boiler room, there was a very hot pipe. The trail in the tailor's basement was interrupted by a stationary wash tub which the ants visited for moisture and then returned to continue the trail along the drain pipe, through a hole in the wall into the boiler room where the temperature was very high. It then proceeded into a hole in the concrete floor. At this point the insect traffic was sufficiently high to suggest the presence of a nest beneath the floor. The temperature in the boiler room was extremely high, and no wall trails were seen. On the other hand the coal room

*Contribution No. 27, Plant Protection Division, Department of Agriculture.

adjoining had a lower temperature, but was still quite warm and trails were present on the wall close to the boiler room. All parts of this wall were warm and trails could be marked out like tributaries of a river. These were the only examples of trails other than horizontal and vertical ones which were noted during our observations.

From this information it appeared that the heating system in the buildings may prove to be reliable guides to the presence of trails. In no instance were ants seen to travel directly on hot pipes, but preferred trails close by with a moderate temperature. One hot pipe passed through a basement room which is very cold in winter and none of the tenants served by this pipe were annoyed by ants during the winter weather. Apparently the ants would not travel over the pipe, and the walls were not warm enough during the winter months. In summer, however, when the walls became warm, the insects would resume their march.

These observations were confirmed in another apartment building being treated by the same exterminator. Two large unfinished spaces were beneath the building. These contained heaps of earth which was wet in low places. These spaces were kept closed and the atmosphere was uncomfortably hot. Each had two walls adjacent to the outside earth which were cool and appeared to have no trails. Walls in the middle of the building were warmer and bore trails. The fourth wall in one room was adjacent to the boiler room, and bore three horizontal trails with a number of vertical tributaries to the apartments in the building and also to the earth.

An explanation for the horizontal trails at varying levels might be that the temperature in these spaces varies with the amount of firing of the boilers. In cold weather, when there is extra firing, the ants might be more comfortable at a lower trail. On one mild day it was observed that all the trails were active. The temperature on this day at the highest horizontal trail was 82° F. and 80° F. at the lower. The temperature at the soil level at the foot of the wall was 78°. The temperature in the middle of the space was 84°. A telephone ground wire which extended from the wall across two beams bore a trail as far as the first beam, from whence it led along the beam to the wall. Directly beneath this right-angled trail was a right-angled hot water pipe, the temperature at the wire being 86° F.

The temperature in the second space although warm, was lower. The fourth wall was adjacent to the locker room on which two horizontal trunk lines with vertical tributaries were noted. One nest was found amongst the brick construction midway along the wall where the temperature was 82° F. and two other nests on the top of the wall where the temperature was nearly 86° F.

From the above observations the following conclusions have been drawn:

1. In establishing nesting places and in travelling in search of food, the Pharaoh's ant requires a high degree of temperature.

2. They depart from main trails only for short periods to obtain food and moisture indicating a reluctance to be away from heated surfaces.

3. Preferred temperatures appear to be between 80° and 86° F.

4. In all cases the restricted trails in rooms of normal temperature were in strong contrast to the multiple trails noted in rooms of high temperature.

5. That trails leading to earth do not necessarily indicate the presence of a nest Such earth may provide the required moisture only.
6. It is evident that abundant moisture supply is essential to an ant colony.
7. Sources of infestation are most readily determined by concentrating on the examination of areas adjoining heating systems.

THE RELATIVE SUSCEPTIBILITY OF THE SEXES OF *DROSOPHILA MELANOGASTER* MEIGH., TO NICOTINE (ALKALOID) USED AS CONTACT INSECTICIDE.*

By F. T. Lord,

Dominion Entomological Laboratory, Annapolis Royal, N. S.

Drosophila melanogaster Meigh. has been used extensively at the Entomological Laboratory, Annapolis Royal, N. S., in testing contact insecticides, and also to a certain extent in making tests of chemicals as stomach poisons. It has been found to be of considerable value in making comparative tests of related poisons or in related series involving the same poison. Also, where nothing is known of the toxic qualities of a chemical, positive results with this insect are of value in that they indicate that the chemical possesses insecticidal qualities. In the biological testing of insecticides no one species of insect can be used to test the value of poisons to insects in general. Within the limitations mentioned *D. melanogaster* has been found a good test insect since large numbers can be reared in a short time in a small space with readily available equipment.

While it has been possible to make comparisons of a group of poisons it has been necessary to repeat the tests on a number of different days to make them statistically significant. Eight to ten or even more repetitions have been the practice. Usually the ratio of the mortalities resulting from a number of test materials is about the same from one repetition to another, but the level of kill from all materials may be higher or lower on successive days. No doubt a number of interrelated factors govern this variation, among them the sex ratio of the batches of flies used coupled with a different degree of susceptibility on the part of the two sexes to contact poisons.

With the technique used in the experiment herein described the number of females produced almost always exceeds that of the males but a considerable variation in the sex ratio occurs from one day to another. In making up the spraying tubes the male flies emerge from the separatory funnel more readily than the females so that the first group of tubes made up usually contain a preponderance of males in spite of the fact that the females are in excess of the males in the whole batch. Thus if *all* the flies in the separatory funnel are not used in the spraying operations the sex ratio of the sprayed flies approaches more closely to a 50-50 relationship than that of the total flies in the funnel.

Thus is can be seen that some form of randomization of the spraying tubes is very necessary to equalize the numbers of males and females in each lot of tubes to be sprayed. The other factor, that of keeping the sex ratio the same in the sprayed lots from one duplicated test to another, is more difficult of solution and at present none is offered. Attempts have been made to solve this problem but to date none have been successful.

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*Contribution No. 1242, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Rearing technique

A method of rearing *Drosophila* in which boiled potatoes and yeast was used as a rearing medium has been described by Stultz*. In the present experiment somewhat similar methods were employed, no change being made in the type of egg-laying cage or rearing jars. One Royal yeast cake was ground up in a mortar and mixed with ¾ lb. of boiled potatoes, the mixture then being placed in a waxed paper tray 4″ x 6½″ x 1″. This tray of medium was placed in an egg-laying cage for 3 days and then transferred to a rearing jar. The flies began to emerge after the medium had been in the rearing jar for about 13 days. By the 17th day most of the flies had emerged so the jar was cleaned out on that day. Each day a new culture was made up and the material in the oldest jar destroyed. Each day also the flies were removed from the 5 jars in which emergence was taking place and transferred to an aging cage, where they were fed on 5 per cent honey solution for 24 hours and then sprayed.

Spraying Procedure

In performing the tests to determine the relative susceptibility of the two sexes to contact poisons the following procedure was adopted. When ready to begin spraying operations the flies were transferred from the aging cage to a chemical separatory funnel from which the spray tubes were charged with flies. These spray tubes were 22 mm. in outside diameter by 45 mm. in length and covered at both ends with scrim of 35 meshes to the inch. About 20 to 30 flies were used per tube and, in this experiment, 20 tubes were sprayed in each replication with 1 ml. of 0.25 per cent "Britnico" nicotine alkaloid. The sprayer used was of the paint gun type, operated at 12 lb. air pressure per square inch. The tubes for spraying were placed vertically under the sprayer at a distance of 8 inches. After a one hour drying period the flies were removed to feeding vials of the same diameter as the spray tubes and 75 mm. in length. The food medium consisted of 5 per cent honey solution on an absorbent cotton wad fitted into a plug of wire screening which just fitted the open end of the vial.

Twenty hours later the dead and living in each vial were separated and their sex determined. Table I shows the mortality of male and female flies and the average of both for 9 replications sprayed on 9 different days.

Table No. I

Susceptibility of male and female *Drosophila melanogaster* Meigh. adults to "Britnico" nicotine alkaloid (0.25 per cent.) Mortality from nine repetitions.

Replication No.	*Mortality of male flies* *No. sprayed*	*% dead*	*Mortality of female flies* *No. sprayed*	*% dead*	*Total Mortality from both sexes* *No. sprayed*	*% dead*
1	284	42.7	403	30.3	687	35.4
2	373	40.0	246	28.5	619	35.0
3	355	45.9	330	30.6	685	38.5
4	222	31.1	220	20.5	442	23.8
5	219	46.2	302	34.5	521	39.3
6	290	50.3	277	37.2	567	43.9
7	243	47.7	365	43.2	608	44.4
8	360	34.4	318	24.2	678	29.6
9	330	35.2	438	29.9	768	32.2
Total	2676		2899		5575	
Average		40.5		31.2		35.8

*Stultz, H. T. 1940. Methods and materials for a new technique for using pomace flies in biological tests with contact insecticides. 70th Annu. Rept. Ent. Soc. Ont. pp. 72-80.

A later experiment, in which the amount of yeast used in the culture was varied, further substantiates these results as well as throwing some light on one of the factors to be controlled in rearing larvae. Since it is highly probable that a weak or under-nourished larva will produce a weak adult, tests were run to measure the effect on adult susceptibility to nicotine in relation to the amount of yeast present when the culture was initiated. Three cultures were made up each consisting of ½ lb. of boiled potatoes with ½, 1 and 2 Royal yeast cakes respectively. These were left in the egg-laying cage for 3 days and then transferred to gum-jar rearing cages. This series of cultures was made up on 5 different days. When the flies began emerging, 2 lots of flies were removed from each culture on successive days. For example, flies were removed from culture No. 1 (½ yeast cake + ½ boiled potatoes) on November 28 and sprayed on November 29. A second lot of flies were removed on November 30 and sprayed on December 1. Thus 10 separate lots of flies were sprayed with 0.25 per cent "Britnico" nicotine alkaloid from each of the jars represented in the series. Each spray tube was treated with 2 ml. of nicotine solution to insure more thorough wetting of the flies. In Table II each pair of results from the same jar have been averaged and tabulated.

Table No. II

Susceptibility to Nicotine Alkaloid of Adults of *Drosophila melanogaster* Reared on Potatoes plus Varying Amounts of Yeast.

Reared on ½ lb. potatoes + ½ yeast cake				*Reared on ½ lb. potatoes + 1 yeast cake*			
Males		*Females*		*Males*		*Females*	
Flies sprayed	*% dead*	*Flies sprayed*	*% dead*	*Flies sprayed*	*% dead*	*Flies sprayed*	*% dead*
170	41.8	326	27.3	260	32.7	344	24.7
222	65.8	343	59.2	290	59.3	361	43.2
227	69.6	368	55.7	236	61.4	429	50.6
259	79.5	227	65.6	238	61.8	259	42.9
207	79.2	327	62.1	202	59.9	313	47.3
Average	68.7		53.4		54.6		42.0

Reared on ½ lb. potatoes + 2 yeast cakes				*Average Mortality for flies reared on ½ lb. potatoes +*		
Males		*Females*				
Flies sprayed	*% dead*	*Flies sprayed*	*% dead*	*½ yeast cake*	*1 yeast cake*	*2 yeast cake*
342	22.9	525	17.3	32.2	28.1	19.5
251	72.9	274	52.6	61.8	50.4	62.3
233	57.5	296	42.9	61.0	54.4	49.3
208	54.5	289	38.1	73.0	51.9	44.9
220	64.1	282	46.8	68.7	52.2	54.4
Average	51.7		36.2	59.6	47.3	42.9

Tables I and II both show that the male adults *Drosophila melanogaster* Meigh. are more susceptible to nicotine alkaloid than female adults. The amount of yeast on which the larvae are reared has an influence on the susceptibility of the adults of both sexes to nicotine alkaloid. Those reared on 2 yeast cakes per ½ lb. of potatoes show only slightly greater resistance than those reared on 1 yeast cake to ½ lb. of potatoes.

SOME RECENT EXPERIMENTS ON THE CONTROL OF THE STRAWBERRY WEEVIL *ANTHENOMUS SIGNATUS* SAY.*

By C. W. B. Maxwell

Dominion Entomological Laboratory

Fredericton, N. B.

Although the sulphur-lead arsenate 85-15 dust combination has proved an effective insecticide in some parts of North America for control of the strawberry weevil, *Anthonomus signatus* Say, this material has not provided satisfactory control in the Maritime Provinces. During the past three seasons the writer has tested various insecticidal dust combinations in the field for control of this insect, with the object of discovering a mixture which will prove more effective than the recommended sulphur-lead arsenate dust. With the expectation that some cultural practice may be of benefit in combatting this pest, endeavors have also been made to collect some information on the movements of the insect with reference to its hibernation in the plantation.

Weevil Prevalence and Hibernation in Plantations.

The heaviest infestations of weevils usually occur in plantations which are producing their second crop. Plantations in their first bearing year are not usually heavily infested; occasionally, however, they may be very severely attacked. The heavier infestation of two-year-old plantations is probably brought about by a build-up in population from the previous year within the plantation, increased in some cases by an influx of weevils from adjoining or nearby new plantations attracted by the earlier development of buds.

To discover whether weevils hibernated within the plantations, cages were set out in autumn and covered in the early spring before insect activities began. These cages, of pine boards, were ten feet long, eight feet wide and nine inches high, covered with black asphalt building paper. Shell vials one inch in diameter were inserted in holes bored through the sides of the cages. Weevils appeared in the vials from a week to ten days earlier than the first evidence of them was seen in the field and the last few were usually recovered in the cages before bud-cutting got well under way. The temperature within the cages was from 10 to 33 degrees higher than the outside temperature, the extent of the range depending on the general outside temperature and whether or not the sun was shining.

In the spring of 1940, totals of 76 and 31 weevils were recovered in two cages covered on May 16 and 17 respectively. Weevils did not begin to appear in the vials until the sixth day after the cages were covered, 80 per cent of the total collection being obtained on this and the following day. In the fall of 1940 the cages were removed to other plantations, and on April 22, 1941, they were again covered. Sixteen weevils were obtained from one cage and 15 from the other. In connection with another project, 8 weevils were obtained the following spring from one 3-foot square cage left covered all winter. Records of weevils collected from 3-foot square cages during the bud-cutting season show a heavy infestation occurs when the weevil prevalence amounts to approximately one per square foot of cage.

Tests are under way at the present time to check these results.

No weevils have been recovered from cages set up in pastures, hay fields, and near bushes and fence rows adjacent to plantations. A few were recovered in plantations by sweeping during July and August but none were obtained by this

*Contribution No. 2137, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

method in fields surrounding the plantations. However, since the weevils can fly for considerable distances and so may spread over a considerable area these findings do not necessarily mean that the weevil may not inhabit such locations.

During the late fall of 1939 and the early spring and late fall of 1940 some thousands of weevils were recovered from a raspberry plantation by carefully removing to the laboratory debris collected about the bases of the canes. This material was placed above a coarse screen in a temperature cabinet and heated to 80°F., whereupon the weevils became active and upon disturbance of the debris dropped to the floor of the cabinet. Litter from the area surrounding this plantation was examined but no weevils were recovered.

It would appear, from the results of these experiments, that the great majority of the weevils hibernate within strawberry and raspberry plantations.

The question of hosts other than the cultivated and wild strawberry and raspberry has been given attention, but no evidence has been secured to indicate the weevil normally feeds upon or infests plants other than these, although they will live in captivity when fed on other flowering plants.

Field Tests of Insecticides.

Field tests for control of the strawberry weevil were begun during the bud cutting period of 1939. A two-wheeled power duster of the cranberry type, pulled by hand, and equipped with a trailing canvas was used in all tests, unless otherwise mentioned. The dusts were applied at approximate rates of fifty pounds per acre at any time during the day providing conditions were satisfactory. The results of the treatments were obtained by examining approximately 2000 buds from each dusted plot a short time previous to the first picking. In 1939 seven dust mixtures were tested in duplicate on various two-year-old plantations located in the Belleisle and Washademoak areas of New Brunswick.

The average results of these tests are shown as follows:

TABLE No. I.

RESULTS OF 1939 FIELD TESTS.

	Percentage buds cut
Sulphur-lead arsenate 85-15 dust	30.9
Sulphur-pyrethrum 70-30	22.2
Sulphur-cryolite (synthetic) 85-15	19.5
Sulphur-cryolite (synthetic) 70-30	18.9
Gypsum-pyrethrum 70-30	12.2
Gypsum-cryolite (synthetic) 85-15	20.6
Gypsum-cryolite (synthetic) 70-30	8.2

Results of these tests indicate that gypsum mixtures may be as effective as sulphur mixtures and that cryolite may be as effective and more economical to use than pyrethrum.

In 1940 the field tests were continued; the results of two applications of dust applied 10 days apart are shown in the following table:

TABLE NO. II

RESULTS OF 1940 FIELD TESTS.

Treatment	Percentage of buds cut				Weevils recovered 48 hours after dusting
	Series 1	Series 2	Series 3	Average	
Sulphur-cryolite (natural) 70-30	19.7	16.7	30.3	22.4	1
Sulphur-cryolite (natural) 85-15	19.3	20.1	32.5	23.5	2
Gypsum-cryolite (natural) 70-30	17.6	15.8	22.9	19.2	0
Gypsum-cryolite (natural) 85-15	26.4	16.6	22.0	21.4	3
Sulphur-lead 85-15	26.5	21.8	30.9	26.3	4
Sulphur undiluted	23.8	27.6	29.7	26.2	10
Cryolite (natural) undiluted	12.7	14.5	25.4	17.5	0
Cryolite (synthetic) undiluted	18.7	18.1	17.7	18.2	2
Check	....	....	....	29.4	14

These results further indicated the effectiveness of the gypsum-cryolite mixtures and it was therefore decided to discontinue further tests with sulphur-cryolite combinations. It was noted that natural cryolite was not buoyant enough to apply in undiluted form.

To compare the prevalence of weevils in plantations before and after dusting wooden cages three feet square and nine inches high, topped with black asphalt building paper, were set out. Shell vials one inch in diameter and six inches long were located in the sunny sides of the cages. In Series I, an average of 5.5 weevils were recovered per cage before dusting and 1.0 weevil per cage 48 hours after dusting. In Series 2 and 3, 9.17 weevils per cage were recovered before dusting and .9 weevils per cage 48 hours after dusting. It is possible the weevils captured after dusting flew in from other sources but there was no evidence of this. The sudden apparent scarcity of weevils and lack of bud-cutting the day following the first application was striking.

In 1941 only one application of the experimental dusts was made. This was applied to Series 1 and 2 on May 30 and to Series 3 and 4 on June 2. Little or no rain fell during the following two weeks so that the plants retained a coating of dust during this period, making a second application unnecessary.

With the exception of the check plots the results of the various tests in 1941 show, in general, less bud-cutting than in 1940. This was due to the first application of 1940 being applied a little late, more buds being cut at this time than in 1941 when the application was made. The effectiveness of the gypsum-cryolite 70-30 mixtures in 1941 is shown. In the 30 per cent cryolite dusts the synthetic material shows slightly less bud-cutting than does the natural material. As previously mentioned the natural cryolite has a higher density than the synthetic material and it would, therefore, seem that the latter type is preferable. There is considerable consistency among the plots dusted with 20, 40, and 60 pounds per acre. These were applied with a hand duster. Very little less insect injury is indicated in the 60-lb. plots than in the 40-lb. plots. It would appear that the 70-30 gypsum-cryolite mixture applied at the approximate rate of 50 pounds per

TABLE No. 3.

RESULTS OF 1941 FIELD TESTS

Treatment	Percentage of buds cut				Total no. buds examined	Average Percentage of buds cut
	Series 1	Series 2	Series 3	Series 4		
Sulphur lead 85-15	30.2	25.4	34.0	19.2	8501	27.2
Gypsum cryolite (synthetic) 70-30	12.4	11.2	18.2	10.7	8538	13.1
Gypsum cryolite (natural) 70-30	12.0	14.6	18.9	19.9	8469	16.2
Gypsum cryolite (synthetic) 85-15	16.2	18.8	23.7	24.5	8801	20.8
Gypsum cryolite (natural) 85-15	22.9	20.7	24.5	14.9	8533	20.8
Cryolite (synthetic) 20 lb. per acre	16.7	12.3	24.6	11.4	8625	16.4
Cryolite (synthetic) 40 lb. per acre	8.8	8.6	20.5	17.2	8713	13.8
Cryolite (synthetic) 60 lb. per acre	7.9	8.1	18.8	15.3	8541	12.4
Check	34.3	28.4	37.4	....	6423	31.5

acre is more effective than an application of undiluted cryolite applied at 20 or even 40 pounds per acre.

Conclusions.

Strawberry weevils in sufficient numbers to cause heavy infestations were recovered from cages set out in one-year-old strawberry plantations during months of insect inactivity, indicating that the weevils must have gone into hibernation within the plantations. Examination of debris obtained from a raspberry plantation moderately infested with the strawberry weevil resulted in the collection of some thousands of weevils proving that they also hibernate in raspberry plantations.

Hosts other than the cultivated and wild strawberry and raspberry were not found in the strawberry-growing districts.

Sulphur-lead arsenate 85-15 dust has proved to have little effect in the control of the strawberry weevil. Gypsum-cryolite 70-30 dust has been the most effective of the materials tested. Used undiluted the physical properties of synthetic cryolite proved more satisfactory for dusting purposes than natural cryolite.

NOTES ON THE EGG MASSES OF THE WHITE-MARKED TUSSOCK MOTH

By L. CAESAR, *Guelph, Ont.*

The white-marked tussock moth, *Hemerocampa leucostigma* S. and A., as is well known, passes the winter in the egg stage. The eggs are embedded in a white material, which holds them together and fastens the mass to the bark of the tree or any other object on which it may have been deposited. As the binding material also covers the surface of the mass, it helps to protect it against wind and the washing effect of rain. Whether it gives any protection against low temperatures is doubtful

A common control practice is to remove the egg masses when the foliage is off the trees and the masses can thus be seen easily. Sometimes a wire brush is used to tear the masses off. The writer has not looked over the literature to see what tests have been made to determine the effect upon the hatching of the eggs when the masses are thrown on the ground and allowed to remain there. He wished, however, to test this for his own satisfaction and for the benefit of others who might ask for information.

In the fall of 1940 in Queen's Park, Toronto, 120 egg masses containing approximately 18,000 eggs were gathered and taken to Guelph and placed in the soil in the writer's garden in the following ways: One lot was placed in a water-tight glass container to keep out rain and snow. A second was placed in a similar container covered only with a light linen cloth and the container then set on its side so that any rain or water entering would run out. A third lot was also put into a glass container set on its side but left uncovered. A fourth lot was wrapped in cellophane. A fifth was wrapped in a linen handkerchief. The remainer of the egg masses were simply left uncovered.

All the above lots were placed on level ground at intervals of about three inches, and they were all set out at the same time; namely, just as cold weather was beginning and the soil had become frozen. None of them was disturbed until March 31st. At that date the snow had all disappeared and the danger from birds and from the heat of the sun beating upon the glass containers made it desirable to take them all up and set them out anew on a piece of cloth laid on the ground.

Each lot had its own assignment and then the whole was covered with mosquito wire netting to keep them in place and ward off birds or other marauders.

On May 2nd, when the weather was getting quite warm and the heat of the sun on the soil suggested that hatching might take place early, each lot was taken out and placed in a glass vessel and covered to prevent escape of any larvae or parasites. All were then stored in the kitchen where the daily temperature varied from about 60° to 72° F.

Hatching began before the end of May and continued for two weeks or more. On June 24th, when it was certain that no more eggs would hatch, the containers were all carefully examined and a count made of the number of eggs in each container and also of the number of larvae that had emerged.

Results

1. From the lot that had been kept in the water-tight glass container until March 31st and then set out under the wire protector approximately 13 per cent of the eggs hatched.

2. From the lot in the cloth covered glass and also in the uncovered glass approximately 24 per cent hatched.

3. From the lot in cellophane approximately 50 per cent hatched.

4. From the lot in the handkerchief and also from the uncovered lot approximately 76 per cent hatched.

5. To serve as a partial check a large egg mass of approximately 400 eggs was brought into the house from a tree in Guelph on March 23rd and from this 370 larvae emerged or approximately 92 per cent.

Comments

1. No treatment destroyed all the eggs.

2. The two treatments that were thought by the writer likely to give the highest mortality; namely, the ones where the eggs were either completely exposed to the weather or were protected only by a thin handkercheif, gave much the highest hatch—76 per cent. In both of these lots the solvent action of repeated rains and melting snow had disintegrated the egg masses and left the eggs loose, whereas in all the other lots the masses were very little if at all disintegrated, apparently because they did not receive sufficient moisture. This would indicate that the use of a stiff wire brush to tear the egg masses from the trees would not be any more satisfactory than throwing the unbroken or broken masses on the ground beneath the tree.

3. The tests as a whole seem to indicate very strongly that the percentage of hatch was determined largely by the amount of moisture in contact with the eggs.

4. There is no good reason to believe that the surface covering of the egg masses on the trees is essential to their hatching; many of these masses have the surface largely broken or removed even before winter. Such masses are apparently just as likely to hatch as those with the surface intact.

5. If control is being sought by the destruction of eggs the method recommended by several prominent entomologists; namely, applying creosote or creosote oil blackened by lampblack to the egg masses, would seem to be as satisfactory as any. The lampblack is used merely to show what masses have been treated.

6. The fact that eggs left on the ground over winter will hatch does not, of course, mean that all the larvae will reach the trees; many of them probably will not.

In conclusion it may be interesting to note that only two egg parasites were found in the 18,000 eggs examined. These were black in color and active.

NOTES ON THE LABORATORY PROPAGATION OF THREE EUROPEAN SPECIES OF *EXENTERUS* (ICHNEUMONIDAE), PARASITIC ON SAWFLIES.*

By A. WILKES

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In an effort to establish factors of control on sawflies, several groups of parasites have been released in Canada and the New England States. Among those of importance are several European species of the ichneumonid genus *Exenterus*. Their liberation and subsequent recovery have been reported in a number of papers by Baird and Balch (vide Baird 1939, 1940 and Balch 1940).

The further distribution of three of these, *Exenterus marginatorius* Fabr., *E. claripennis* Thom., and *E. abruptorius* Thb. at the present time is considered of the greatest importance. The source of European parasites has now, however, been cut off, leaving only a very small number remaining in diapause from collections made prior to the outbreak of war. In addition, the great reduction in the population of the European spruce sawfly, particularly in New Brunswick and at Parke Reserve, Que., is making it extremely costly to collect material in sufficient numbers for redistribution of these parasites in Canada. Thus it was considered advisable to undertake investigations in an attempt to develop a practical laboratory breeding method and at the same time provide as many parasites as possible for liberation during 1941. The purpose of this paper is to give a very brief account of these studies with special reference to points of more general interest in insect propagation.

The progress of this work was greatly facilitated by the generous co-operation of the United States Bureau of Entomology, particularly the gratuitous services of Mr. W. F. Sellers during the initial phases of the project, and by the assistance of Dr. A. S. West, Jr., Professor of Forest Entomology at the University of New Brunswick, throughout the current summer months.

Method of Propagation.—The methods of propagation developed are in general similar for the three species and consist essentially of placing together last stage sawfly larvae with mated female parasites. The cages usually used are small (approximately 3 in. square) with cotton gauze on three sides and movable celluloid fronts. The parasite eggs are deposited externally, and from time to time, the host larvae are examined and those found to be parasitized are removed and allowed to spin-up in damp sphagnum moss. The spin-ups are later placed individually in vials and removed to an incubator operating at 74° F. and 80% R. H., where they remain until the adult parasites emerge. At this temperature emergence usually takes place in 20 to 30 days.

Discussion of Results.—The results obtained are shown in Table I. The table includes records of one incomplete parental generation of *Exenterus abruptorius* Fabr. and one parental and three filial generations of *E. marginatorius* Thom. and *E. claripennis* Thb.

*Contribution No. 2135, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE No. I.

A summarized record of *Exenterus* propagation in 1941.

	No. Sawfly larvae parasitized	No. parasitized spin-ups	Parasite Emergents			Sex ratio of emergents (percent ♀♀)	% parasites in diapause	Mean adult longevity in weeks	Mean number eggs per female
			males	females	Total				
E. marginatorius									
mated ♀♀	1563	1404	264	358	622	57	55.7	6	21
virgin ♀♀	423	361	150	0	150	0	58.4		
E. claripennis									
mated ♀♀	1273	1181	165	204	369	55	68.8	7	12
virgin ♀♀	683	581	225	0	225	0	61.2		
E. abruptorius									
mated ♀♀	2046	1759	0	0	0		100.	3	31
	5988	5286	804	562	1366				

Although a complete discussion of the results cannot be made until further breeding has been completed, a few points of interest should be noted. It will be noticed that some 12 per cent of the parasitized larvae failed to form cocoons. This was due largely to a lack of suitable conditions during the spin-up stage of development and was usually attributable to insufficient moisture in the sphagnum moss.

The occurrence of diapause, doubtless influenced by various factors, both inherent and external, is involved to varying extents in the three species. Under the constant temperature and humidity conditions indicated above approximately 55 to 68 per cent of the parasites in the case of *E. claripennis* and *E. marginatorius* remained in diapause. There appeared to be no difference between the sexes in the number going into diapause. In both species the sex ratio of the emergents was approximately 50 per cent females. There did, however, seem to be a greater tendency for diapause on the part of both sexes of *E. claripennis*. In the case of *E. abruptorius* no emergents have appeared to date, hibernation taking place in the prepupal stage.

The host larvae used in these experiments and from which the above records were taken included the following sawflies, *Neodiprion abietis* Harr., *N. dubiosus* Schedl., *N. sertifer* Geoff., *N. lecontei* Fitch., *Diprion similis* Htg., *Gilpinia hercyniae* Htg. and a jack pine sawfly (*Neodiprion* sp.). Oviposition and development of *E. marginatorius* and *E. claripennis* have been successfully completed on all the sawflies tested. The results from *E. abruptorius* ovipositions are as yet unknown, since the parasites are still in diapause.

Biology and Habits of the Adults.—The length of life of the three species was somewhat variable. Adults confined in cloth covered cages and fed daily on a 10 per cent honey solution lived from approximately 3 to 7 weeks. In *E. claripennis*, 98 individuals had a mean longevity of 54 days; in *E. marginatorius*, 146 had an

average longevity of 40 days and in *E. abruptorius*, 89 lived an average of 20 days (Table I). Several females of the first two species were kept alive for over 13 weeks.

The oviposition habits are, with few exceptions, very similar among the three species. In all, the preoviposition period was short; the females laying freely at approximately 24 hours after mating. As is usual for this group, the females attacked the free-living sawfly by springing upon the host larvae from the rear and inserting the egg usually in or on the neck by a lightning-like thrust of the ovipositor. The eggs are laid at the rate of up to two eggs per day. Several individuals oviposited at an average of one egg per day for a continuous period of two months. Although the mean fecundity of our laboratory stock seemed to be comparatively low, (*E. abruptorius* 31; *E. marginatorius* 21 and *E. claripennis* 12) some females of each of the three species deposited over 80 eggs.

Provided that a suitable supply of host larvae is available, probably the greatest single limiting factor in the propagation of these species is that of mating. Under normal laboratory environments it is singularly difficult and can be accomplished only under a somewhat narrow range of conditions more or less specific for this group. These can be listed briefly as follows:

1. *Age at time of mating.* The males appear to mate most effectively when they are 7 to 8 days old, and the females when they are from 2 to 24 hours old. A few females, however, have mated successfully on the second and third day after emergence.

2. *Segregation of the sexes.* When not being used for mating the sexes should be segregated and confined in separate cages in a darkened room at a temperature near 60° F. At regular daily intervals the parasites should be allowed to feed for about an hour under ordinary room conditions.

3. *Temperature and light.* The optimum environment for mating appears to be found near or on the edge of bright sunlight at a temperature of approximately 73° F. The most suitable temperatures are somewhat narrowly confined to a range between 67° and 80° F.

Such peculiar conditions as to induce mating were at first found only in cages (illustrated in figure I) taken outside of the laboratory at certain periods of the day.

It was found, however, that even under these conditions, at times, mating would not be accomplished and that the stimulus to mate was related to changing temperatures. When later tests were made, it was discovered that a difference in temperature almost always existed between the inside and outside of the mating cage, usually in the order of 4 or 5° F., the higher temperature being inside the cage. Thus a temperature gradient was present on the cloth cover of the cage where mating invariably took place. Experiments were set up in an attempt to simulate these conditions inside the laboratory. By placing the two sexes together in a cage and raising the temperature of the room from 60 to 80° F. at a steady rate of approximately 1 degree per 8 minutes, copulation was readily achieved. Of the 502 *Exenterus* mated during the past season approximately 20 per cent were mated in this manner.

Conclusion.—The investigations reported have shown that the propagation of the three species of *Exenterus*, *E. marginatorius*, *E. claripennis*, and probably *E.*

abruptorius, is both practical and economical under laboratory conditions at Belleville. By the further development of routine breeding methods it would appear possible to produce them far more economically in the laboratory than by field collections for redistribution. The adaptability of the several species of parasites to the different sawflies is also of considreable importance in the distribution and establishment of these parasites in the field.

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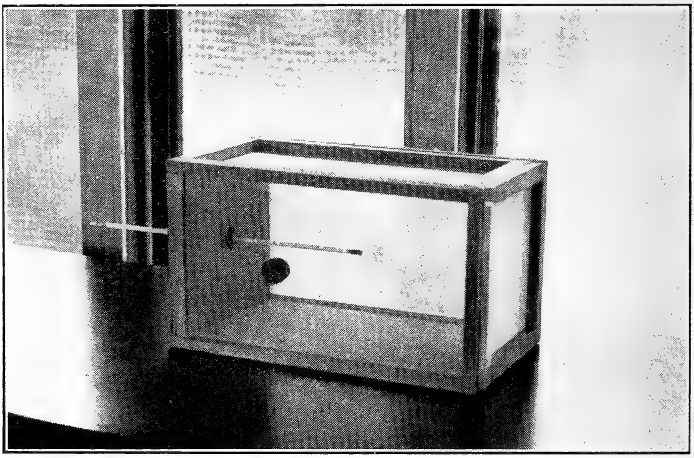

Fig. 1. Type of cage used for mating

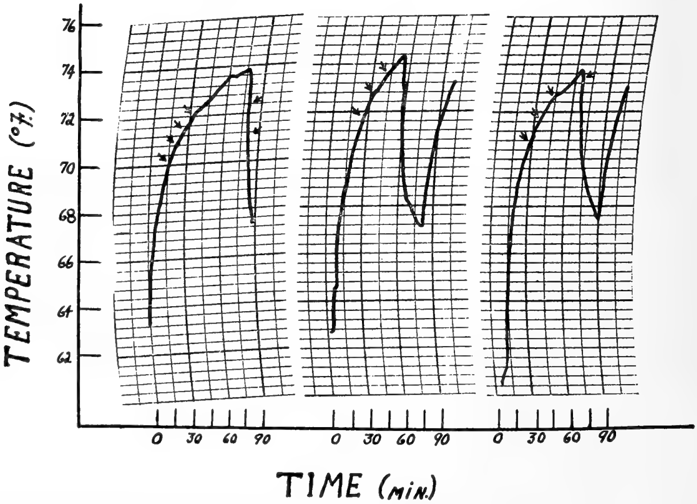

Fig. 2. Graphic presentation of the temperature changes in the room during mating. The arrows indicate the points at which mating took place.

OBSERVATIONS ON THE BIOLOGY OF *MANTIS RELIGIOSA* L.*

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Mantis religiosa L. was first recorded in America at Rochester, New York, in 1899 (Slingerland, 1900). In 1914 it was found at Carrying Place Prince Edward County (Gibson, 1914) and has since become well established along the north shore of Lake Ontario. Recently it was shown (Urquhard and Corfe, 1940) that the range of the mantis now extends from Spencerville and Ottawa on the east to as far west as Fort Erie. The purpose of this paper is to bring together certain data on the fluctuation, seasonal history and food of this predator under Ontario conditions as recorded in the Belleville district between the years 1938 and 1941 inclusive.

Methods: Field sampling was carried out each year in late October to determine the extent of oviposition. Ten or more oothecae were marked *in situ* at each point in the field, and were collected later at the end of the following March. These oothecae were then incubated, the percentage of hatch indicating the effect of overwintering on the eggs. The development and the population of the nymphs and adults throughout the summer were recorded by regular sweeping in the mantis habitats.

Fluctuations: Although figures are lacking on the egg survival in the spring of 1938, there was indirect evidence that the percentage of hatch was high. Third and fourth instar nymphs were commonly observed in July, and adults were also numerous in August and September. In the following spring (1939) hatching occurred in only 20 per cent of the egg cases, and was reflected later in the scarcity of nymphs in July. Only half as many egg cases were deposited in 1939 as compared with 1938. A similar low summer population was recorded in 1940, although egg case survival was between 38 and 40 per cent. In 1941, 67 per cent of the egg cases produced nymphs. In the ensuing summer, all stages were more plentiful than they had been since 1938, and a larger number of oothecae were deposited. Estimates based on 90 sample areas of vegetation ran from 131 cases per acre in low ground subject to flooding to 466 in grasses and weeds in better drained land. The highest estimate were obtained from sampling in almost pure stands of couch grass, (*Agropyron*) which reached 600 cases per acre. Such concentrations, however, were not common, and were limited to quarter and half acre areas of vacant land on the outskirts of the city.

Egg survival: From the data obtained, it would appear that the summer population is determined to a large extent by the number of eggs that survive overwintering. This was also evident from an experiment in 1939, in which numbers of egg cases were subjected to various periods of outdoor exposure during the winter. The first lot of five cases left out until December 1st, yielded a total of 820 nymphs or a 96 per cent hatch. Similar lots that were exposed until the first of January and February yielded only 42.1 per cent and 44.3 per cent hatch. The percentages were further reduced by exposure through February and March. Little is known as to the causes underlying the survival of the mantis eggs. The amount of snow-cover as well as the temperature extremes may be important. In this regard, a reference to the Belleville weather records taken in the winter months preceding the high egg survival of 1938 and 1941 is interesting. As shown graphically in

*Contribution No. 2133, Division of Entomology, Science Service, Department of Agriculture Ottawa, Canada.

Fig. I, the total snowfall in 1938 and in 1941 was greater than in either of the intervening years. It was also more extensive during the early winter months.

Seasonal life-history: During 1939, nymphs, which emerged from an egg case on June 26, were reared through to the adult stage, chiefly as a means of identifying the various instars in the field. Nymphal development under insectary conditions required 64 days, the females undergoing seven moults in all before reaching maturity.

In a normal growing season at Belleville, hatching from the egg cases appears to occur as early as the second week in June. Third and fourth instar nymphs are present in mid July and adults a month later. Oviposition takes place during the last week in August and throughout September. Adults have been recorded as late as October 26, but heavy frosts often occur before this and end their activity. During the exceptional spring of 1941, hatching occurred as early as May 28. Fourth instar nymphs were present by June 30 and adults by Aug. 12. Egg cases were deposited ten days later.

Food of the nymphs: Some preliminary feeding tests with caged nymphs were made in June, 1939, using mainly as food some of the smaller insects that were common to vegetation containing the mantids. Prey that appeared to be more acceptable under these conditions included adults of *Chloropisca globra* Mg (Chloropidae), nymphs and adults of *Deltocephalus inimicus* Say (Cicadellidae) and nymphs of the field cricket *Nemobius*. The two former species were readily disposed of by the second and third instar nymphs. Older nymphs, from the third to the fifth instar seemed to "prefer" *Nemobius* within certain size limits. Among the less desirable prey were adults of *Aphidius* (Braconidae), nymphs and adults of *Acucephalus nervosus* Shrank. (Cicadellidae) and two hymenopterous parasites, *Leptomastix dactylopii* How. and *Leptomastidea abnormis* (Gir.) (Encyrtidae).

Food of the adults: Observations on caged adults were limited to several species of undetermined crickets and grasshoppers that were fed to the mantids in September, 1938. Actual field records of prey were obtained during 1941. These were, Aug. 22 *Gryllus*, Aug. 23 male adult mantis, Aug. 30 *Nemobius fasciatus fasciatus* (DeG), Sept. 5 and 20, *Nemobius*, Sept. 18, *Gryllus assimilis* Fab. These prey were all captured by adult females which were with one exception, brown in colour.

Parasitism: An encouraging feature with regard to *Mantis religiosa* as an agent in biological control in Ontario is the apparent absence of parasites. No parasites were obtained during the incubation of 104 oothecae that had been collected in the field. In Europe, at least, three species of hymenopteorus parasites, two of which parasitize the eggs, have been reported.

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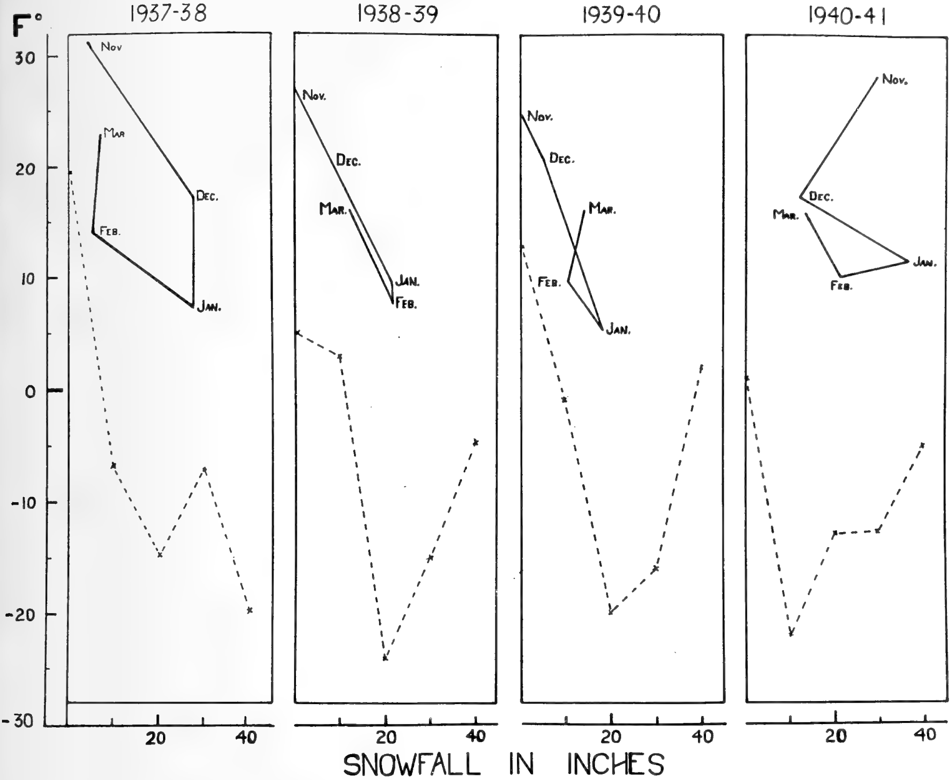

Fig. 1 Partial hytherographs showing relation between monthly mean temperatures and total snowfall at Belleville, Ont. The lower superimposed curves indicate minimum temperatures during the same periods.

A SUMMARY OF THE MORE IMPORTANT CROP PESTS IN CANADA IN 1941

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Field Crop and Garden Insects

Grasshoppers were abundant in the Prairie Provinces during 1941, but did not occur in outbreak numbers, or cause as much damage as in previous years. Crop losses were reduced materially in the early part of the season by plentiful precipitation, but damage increased markedly in Saskatchewan and Alberta under dry weather conditions later in the summer. Control campaigns were waged in all three provinces, but in the latter two, the luxuriant early growth deceived farmers as to the extent of the infestation, so that little poisoned bait was applied

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until August and September. Surveys indicate that in 1942 there will be a reduction in the area of intensity of infestation in Manitoba, and a considerable increase in Saskatchewan and Alberta. Fortunately, the areas threatened by severe outbreaks are comparatively restricted, and over the greater part of the region the grasshoppers are not in severe outbreak numbers. Further details by provinces follow.

In Manitoba, the area of grasshopper abundance increased in 1941 by about 12 per cent to a total of nearly 13,000 square miles. Crop losses were generally light. The wet weather in the early summer favoured the spread of the fungus, *Empusa grylli* Fr., which, in southern Manitoba, markedly reduced the numbers of the clear-winged grasshopper, *Camnula pellucida* Scud., and to a lesser extent the two-striped and Packard's grasshoppers, *Melanoplus bivittatus* Say and *M. packardii* Scud. A general reduction of infestation in southern districts was anticipated for 1942, with the main threat occurring in the Winnipeg district.

In Saskatchewan, the lesser migratory grasshopper, *M. mexicanus* Saus., was the dominant species in all areas. Up to mid-July, the outbreak was considered the least severe of any in the past decade. However, with the onset of drought conditions, grasshoppers became more conspicuous and showed a marked increase over much of the province, especially in the west and west-central portions. Considerable damage to later grain crops occurred, and flax suffered heavily in some areas.

In Alberta, good moisture conditions reduced damage in the early part of the season, and the grasshoppers were confined to their hatching grounds until July when, with the arrival of dry weather, they began moving into luxuriously growing crops. Extensive poisoning was done during the latter part of the season with a view to saving cover crops planted to prevent soil drifting. Heavy damage occurred along the margins of wheat fields in a number of localities, and head dropping reduced the yield by one or two bushels per acre in some areas. The insects, however, were greatly reduced as compared with 1940.

In British Columbia, an increase in the grasshopper population was evidenced during 1941, but, on the whole, the province suffered very little damage from grasshoppers. The only reports from other parts of the Dominion referred to southern Quebec, where grasshoppers were found to have increased in numbers over previous years and were injurious in pastures, corn and the margins of grain fields.

The field cricket, *Gryllus assimilis* Fab., was reported to have increased in Manitoba and Saskatchewan. In the former province, during wet autumn weather, the insects clustered in great numbers on stooks of grain and cut much binder twine. They were heavily parasitized by nematodes. In Saskatchewan, it was reported that although sheaves in the stook were almost black with crickets in some instances, no cutting of the twine was observed, indicating that the twine treatments in use were effective.

The wheat stem sawfly, *Cephus cinctus* Nort., occurred in general abundance throughout the Prairie Provinces. In Manitoba, the infestations were negligible to light, although occasionally, throughout the second prairie level, north to the Riding Mountains severe marginal damage could be found. In this province, the species is held in check by the present crop rotation systems. However, losses were severe and widespread in Saskatchewan and Alberta, following a season of increased abundance and range in 1940. In the western half of Saskatchewan record damage occurred. Some fields were nearly 100 per cent cut, and large districts lost up to 20 per cent of the wheat crop. The losses were most severe in districts where much wheat was planted in stubble land. In southeastern Saskatchewan damage continued light. In Alberta, the sawfly was considered to be probably the most

widespread and serious insect pest of the season. It was found to occur throughout the province from the North Saskatchewan River to the international boundary, and from the foothills of the Rockies to the Saskatchewan border. Apart from the northwestern and extreme southern borders of this area, which contain only traces of the insect, the infestations vary from slight to one hundred per cent in individual fields, with extensive districts having over fifty per cent of the stems infested. Losses were more severe than usual because wet weather delayed harvesting operations, and the majority of the infested stems were cut by the insect and knocked to ground by the rain, where they could not be recovered. It was estimated that over nine million bushels of wheat were lost in Alberta in 1941 owing to this insect.

The eastern wheat stem sawfly, *Cephus pygmaeus* L., was only reported from points in eastern and central Ontario. There was apparently not much change in the infestation as compared with 1940.

The wheat stem maggot, *Meromyza americana* Fitch, was more abundant than usual in western Manitoba, possibly due to better moisture conditions in the early part of the season. Damage averaged one to two per cent and reached five per cent in some cases.

As usual, wireworms were responsible for severe crop losses, especially in the Prairie Provinces, the economic species in that region being *Ludius aereipennis destructor* Brown. Severe damage, involving complete loss in some grain fields, occurred in the Elgin-Fairfax district of Manitoba. In this province, too, losses averaging fifteen per cent occurred in many fields in the Cartwright-Snowflake and Reston districts. The most easterly record was from Stony Mountain where a field of corn was damaged fifteen per cent. In Saskatchewan, serious thinning of wheat on fallow occurred in areas where the soil was dry at seed level. However, considerable loss was also reported in the southeast in spite of a wet spring. Material damage was undoubtedly general to wheat on fallow in light loam and loam soils throughout southeastern, south-central and central Saskatchewan. In west-central and northwestern Saskatchewan damage was estimated at about eight per cent of all wheat seeded on summer fallow, or somewhat less than the usual figure for this area. In north-central and northeast Saskatchewan, damage was light except after recent breaking of cultivated grasses. In Alberta, wireworms were as widespread as usual in wheat fields throughout the province, but losses were very light because abundant rains in late May caused a heavy stooling of the remaining plants in thinned areas. The most serious losses occurred in the Pincher Creek area. In British Columbia and the eastern provinces there were scattered reports of wireworm damage but no widespread losses were indicated.

In Eastern Canada, cutworm damage was reported in New Brunswick, Quebec and Ontario. In New Brunswick, cutworms were numerous in a few localities, especially in gardens, and there were local outbreaks of the bronzed cutworm, *Nephelodes emmedonia* Cram., in bent grass. In Quebec, species of the genera *Euxoa* and *Agrotis* were injurious to a variety of plants in fields and gardens in a number of localities. In Ontario, early season damage by cutworms was much less severe than in 1940. However, during June, extensive injury was done to corn, tobacco, and certain other crops in southwestern Ontario, and the insects were noticed as more abundant than in several years in the Ottawa district. Considerable damage to tobacco occurred in southwestern Ontario in the latter part of July. Small local outbreaks of the armyworm, *Leucania unipuncta* Haw., were reported from Ontario to Saskatchewan.

Except in very restricted localities, the pale western cutworm, *Agrotis orthogonia* Morr., thanks largely to heavy precipitation in the early part of the season which enabled crops to recover, caused little damage in Saskatchewan and Alberta during 1941, and farmers generally suffered practically no economic loss from this

insect. Another species, the red-backed cutworm, *Euxoa ochrogaster* Guen., was also scarce in these two provinces. Some increase of it was noted in Manitoba, however, where it attacked a variety of garden plants.

During August, the wheat head armyworm, *Neleucania albilinea* Hbn., occurred in numbers of varying intensity over a large part of west-central Saskatchewan. In this region, damage by it was estimated at from one-half to five per cent. The losses occurred chiefly to wheat seeded on stubble land. The army cutworm, *Chorizagrotis auxiliaris* Grt., was very abundant in fields throughout southern Alberta during the early spring, but did little damage, thanks to delayed seeding owing to wet weather in April.

There was not a recurrence of the severe 1940 outbreak of the variegated cutworm, *Lycophotia margaritosa* Haw., in British Columbia. Only scattered reports of damage were received in 1941.

For the first time in many years, damage by the hessian fly, *Phytophaga destructor* Say, was observed locally in Manitoba. In Alberta the species has been reported since 1938, and was known to cover a wide area in 1940. It was not reported damaging grain in that province in 1941.

Injury by white grubs, *Phyllophaga* spp., was serious in central Ontario, in the Oshawa district and in the Niagara peninsula and Lambton County, Ontario. In Quebec, such crops as corn and potatoes suffered considerable losses in a number of localities, including Foster, Napierville, St. Jean and Hemmingford. There was local damage to strawberry in Carlton County, N.B., and to potato in parts of the interior of British Columbia.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, was abundant throughout its range. Especially heavy infestations were reported in eastern Ontario, throughout Saskatchewan and northern Alberta. In the latter region the species was reported causing economic loss at Calling Lake, nearly 70 miles farther north than the previous most northerly record. The species was also reported to have been somewhat more troublesome than usual in Manitoba. In the infested Kootenay district in eastern British Columbia, which represents the western limits of the species in Canada, the beetle occurred in very small numbers.

Flea beetles, especially the potato flea beetle, *Epitrix cucumeris* Harr., were abundant and caused economic damage in various localities in the Dominion. The species referred to was very abundant in June on potatoes and related plants, locally in New Brunswick, Quebec and Ontario. The larvae of this or a related species damaged potato tubers in British Columbia by pimpling and pitting them. Flea beetles of other species were reported doing material damage in various localities in the three other Western Provinces.

In eastern and central Ontario, Manitoba, and along the eastern border of Saskatchewan, the sweet clover weevil, *Sitona cylindricollis* Fab., occurred in moderate numbers, and damage to sweet clover was still further reduced from that reported in 1940.

Several species of blister beetles were prevalent in 1941. Local damage by three species was reported to flax, caragana and flowering plants in Quebec. Flower gardens also suffered damage in the Ottawa district, eastern Ontario. Blister beetles fed on the foliage of weeds and several kinds of cultivated plants in the Prairie Provinces. Among these the spotted blister beetle, *Epicauta maculata* Say, attacked beets in the Picture Butte-Iron Springs-Tourin area, and caused local severe defoliation.

As was the case in 1940, the imported cabbage worm, *Pieris rapae* L., was prevalent and abundant from Nova Scotia to Saskatchewan, and caused heavy

losses to cruciferous plants, notably cabbage and sweet turnip. While the species occurred generally throughout southern Alberta, its numbers continued to be noticeably less than in past years.

There was apparently no repetition of the 1940 outbreak of the diamond-back moth, *Plutella maculipennis* Curt., in the Western Provinces where it was an important pest of crucifers in 1940. Its presence in considerable numbers was noted on cabbage and turnip, locally in New Brunswick and Quebec.

Only minor damage was caused by the cabbage seed weevil, *Ceutorhynchus assimilis* Payk., on the lower mainland of British Columbia, where it has not yet recovered from heavy parasitism by a species of *Habrocytus* in 1939. It is on the upward trend, however. On Vancouver Island, where the parasite apparently does not yet occur, it again caused heavy losses to cruciferous seed crops.

Root maggots took their annual toll. The cabbage maggot, *Hylemyia brassicae* Bouche, was reported abundant in many localities in Eastern Canada, and occasioned some severe losses, especially of cabbage and cauliflower. In one locality in the interior of British Columbia, as high as twenty-five per cent of early cabbage plantings were destroyed, but later plantings produced good crops. Local severe damage to onions by the onion maggot, *H. antiqua* Meig., was reported in Ontario, Manitoba, Saskatchewan and British Columbia. In southern Alberta, the species was not as abundant as usual. The seed corn maggot, *H. cilicrura* Rond., was particularly injurious to beans in Nova Scotia, and to corn in several localities of southern Quebec. Some injury to bean plantings was reported in southern Ontario, but there was probably less damage by the insect than in 1940.

There was a great reduction in the infestation of the European corn borer, *Pyrausta nubilalis* Hbn., in Ontario and Quebec during 1941. In the counties in southern Ontario where clean-up regulations are enforced, the reduction in percentage of infested stalks varied from 50 to 75 per cent. Canning corn was generally much more lightly infested than in 1940, but some injury occurred to early table corn despite the reduction in numbers of the borer. In southern Quebec the average infestation in ears of corn at harvest time did not exceed one per cent. Weather conditions, as well as the clean-up campaign and delayed planting, were responsible for the reduced infestation in the two provinces.

An increase in the abundance of the corn ear worm, *Heliothis obsoleta* Fab., was indicated over a wide area of the Dominion by reports received from Nova Scotia, Ontario, Manitoba and Alberta. Damage to late sweet corn and husking corn occurred in Ontario and locally in Manitoba, and extensive acreages were severely infested in southern Alberta, where as high as 20 per cent of the ears of early corn grown for canning were unfit for use in some fields. In British Columbia, where this pest was common in 1940, it had apparently subsided in 1941.

The beet webworm, *Loxostege sticticalis* L., was again extremely abundant in Alberta, both in the south and the northwest. The outbreak in the south was reported to be the most widespread and serious in the history of sugar beet growing in this region. All beet-growing areas were severely infested and at least two hundred acres were completely destroyed in spite of a vigorous control campaign, and other severe losses were recorded in every district. In the northwest, the insect did considerable damage to field and garden crops, and was responsible for almost complete loss of the alfalfa seed crop in an area southwest of Edmonton. In Saskatchewan, the moths were abundant again this year, but only local damage was done to garden and other crops, the larvae feeding principally on weeds. In Manitoba, there was a marked reduction from the severe outbreak of 1940 in the sugar beet areas of the Red River Valley. During the grasshopper egg survey in the autumn, no prepupal overwintering cocoons were found, in contrast to 1940

when large numbers were present. In the British Columbia-Peace River Block, the beet webworm was reported to have severely damaged garden crops at Pouce Coupe.

Inspections in 1940 revealed that the sugar beet nematode, *Heterodera schachtii* Schmidt, was confined to the Blackwell area in Lambton County, Ont. Five additional fields were found infested in 1941. Steps have been undertaken to prevent or retard the spread of this pest.

A somewhat increased abundance of the tarnished plant bug, *Lygus pratensis* L., was indicated in New Brunswick and Quebec. In the former region this species was especially common on potato in Carlton County, and in the latter, celery was attacked at St. Jean and Ste. Clothilde. The species was apparently present in average numbers in Nova Scotia and Ontario. Dahlias, asters and okra were affected in Norfolk County.

Say's stink bug, *Chlorochroa sayi* Stal., was especially abundant in 1941 in the area north of the Old Man River in the Turin-Cameron Ranch-Retlaw district. An extensive acreage of wheat was damaged, and the resulting yield of grain greatly reduced. The species also occurred locally throughout southeastern Alberta, causing serious crop damage in isolated fields and localities. The losses due to this insect in the province were more extensive and severe than during any period except 1938.

Local damage by the squash bug, *Anasa tristis* DeG., was reported in Quebec and Ontario.

A general increase in abundance of the striped cucumber beetle, *Diabrotica vittata* Fab., was indicated throughout Eastern Canada. In southwestern Ontario, the twelve-spotted cucumber beetle, *D. duodecimpunctata* Oliv., also showed an increase and caused local severe damage.

There was, apparently, not much change in the infestation of pea aphid, *Illinoia pisi* Kalt., as compared with 1940. There was again a severe outbreak in the Taber-Barnwell area of Alberta where many hundreds of acres of canning peas were saved from serious loss by prompt and timely insecticide dusting. Parasites and predators apparently completely eliminated the threat of an outbreak of this species in British Columbia. The infestation in Quebec continued generally light and injury was negligible.

In the Lower Fraser Valley, B. C., the infestation of pea moth, *Laspeyresia nigricana* Steph., still further increased; the pod infestation being estimated at 36 per cent in 1941 as compared with 28 per cent in 1940. The actual loss would range from 20 to 40 per cent. In Quebec, the infestation at Aubrey and St. Chrysostome was estimated at two per cent. Local damage to garden peas occurred in the Fredericton district, New Brunswick.

Infestation by the pea weevil, *Mylabris pisorum* L., was more general in the pea-growing areas around Vernon and Armstrong, B. C., than in 1940, but the percentage loss was less. About 2700 acres are involved in these areas. There is another pea-growing section at Creston consisting of about 5,000 acres of field peas grown for seed. In this locality the weevil is at present very scarce, and also occurs only in small numbers in dry-pea fields at Sumas Prairie and at Cloverdale. It apparently is not important in the wet coastal belt.

In 1936, the presence of the carrot rust fly, *Psila rosae* Fab., was recorded in Vancouver, B. C. By 1941, it had spread over all the lower mainland, and was especially destructive. Elsewhere in the Dominion, severe damage occurred in

early carrot plantations in Nova Scotia, but complaints of injury were few in Ontario.

Potato leafhoppers were reported widespread from Ontario to Saskatchewan. In the former province, they were numerous and destructive in potato fields, and necessitated increased control measures.

During 1941 the Japanese beetle, *Popillia japonica* Newm., was again found at Niagara Falls, Ont., and was also located at Windsor.

Fruit Insects

The codling moth, *Carpocapsa pomonella* L., showed an increase in numbers in all the apple-growing regions of Canada during 1941, but injury to the apple crop in general was not much greater than in 1940. In Nova Scotia, increases occurred in central and eastern Kings and Hants Counties, where the insect was a major pest. It was only of minor significance, however, in the western end of the Annapolis Valley. In southern Quebec, although the number of moths was much larger than in 1940 there apparently was no increase in the amount of injury. In Ontario, the early dry and warm season was favourable to the moth and gave rise to a large second brood, which in many orchards resulted in serious damage. Losses throughout the province, however, were not much greater than in 1940. In British Columbia, the flight of moths in the spring was very early, and rain interfered with spraying against the first brood. Later in the summer, conditions were less favourable for the moth, and although damage was heavy, it was less extensive than would otherwise have been the case.

A further reduction in the numbers of the apple maggot, *Rhagoletis pomonella* Walsh, was evident in the Maritime Provinces. A marked decrease in the percentage of orchards infested was also revealed by a survey in Ontario. Apart from spraying practices, this was considered to be due to dry weather which reduced the number of flies emerging from the soil.

The rosy apple aphid, *Anuraphis roseus* Baker, continued scarce in most orchards of the Annapolis Valley and caused little injury to the apple crop. Some damage occurred in a few orchards in the western end of the valley, and in Hants County where the insect is usually troublesome to some extent. The species was of little consequence in Ontario. The green apple aphid, *Aphis pomi* DeG., was generally unimportant in orchards of Nova Scotia and Ontario. In the former province, however, some damage occurred in apple nurseries, and in the latter, the species occasioned some losses in a few orchards in the Niagara and Georgian Bay districts.

There was a further slight decline in the numbers of the gray-banded leaf roller, *Argyrotaenia mariana* Fern., in Nova Scotia. Increased damage by the fruit tree leaf roller, *Archips argyrospila* Wlk., was reported in a number of localities in southern Quebec. This species also increased markedly in Ontario orchards, notably in the Northumberland-Durham districts and in Norfolk County. As high as 50 per cent of the fruit was damaged in a few cases. Certain other species of leaf rollers were also involved in this infestation.

The eye-spotted budmoth, *Spilonota ocellana* D. & S., continued to be an important pest in some orchards of the Annapolis Valley, N. S., especially eastern Kings County. In general, however, it was not an important pest. In Quebec, a few orchards at St. Hilaire and Rougemont suffered appreciable injury. The species continued to be a major pest in eastern and southwestern Ontario. As many as 50 per cent of the buds in heavily infested orchards in Norfolk County were damaged by overwintering caterpillars.

In apple-growing regions of Nova Scotia, Ontario and British Columbia, the white apple leafhopper, *Typhlocyba pomaria* McAtee, was present in only slight or moderate numbers and no severe infestations were recorded.

Increased abundance of the European red mite, *Paratetranychus pilosus* C. & F., was reported in orchards of Nova Scotia and Ontario. In the former province, characteristic bronzing of the foliage was observed in some orchards, but, in general the infestation was reduced by natural enemies. In Ontario, where the mite was more abundant than in 1940, infestations on plum, apple and peach were moderate to severe in character. Local trouble from this mite was reported in apple orchards at Oliver, B. C.

An expected increase of the Pacific mite, *Tetranychus pacificus* McG., in the Oliver region of British Columbia did not occur and the mite population was uniformly low even in orchards where it was numerous last season.

The apple mealy bug, *Phenacoccus aceris* Sig., was observed only in small numbers in a few orchards in Nova Scotia. In British Columbia, it continues to attract attention in the Boswell district, near Nelson. An incipient infestation has been discovered at Kelowna.

A heavy infestation of the European apple sucker, *Psyllia mali* Schmid., was reported in an old orchard on the Kingston Peninsula, N. B.

The oyster shell scale, *Lepidosaphes ulmi* L., has continued to increase in Nova Scotia and New Brunswick. Throughout the central part of the Annapolis Valley it has assumed the status of a major pest, and was also seriously abundant in eastern Kings and Hants Counties, N. S. The commercial orchards along the St. John Valley, N. B., are becoming increasingly heavily infested.

The tarnished plant bug, *Lygus pratensis* L., was numerous on weeds in Nova Scotia orchards but caused less injury by puncturing fruit than in 1940. In the Niagara district, Ontario, it was very destructive to peach nursery stock, and in one nursery at Vineland Station, more than 30,000 nursery trees suffered "stop-back" injury. Damage by this insect was also extensive on apple and pear trees throughout the Okanagan Valley, B. C., with resultant serious crop reduction in many orchards.

The pear psylla, *Psyllia pyricola* Forst., was more abundant and injurious in the Niagara district, Ontario, than it had been in any other season since 1927. Weather conditions were conducive to the increase of the insect, but, in addition, the dormant application of oil was less effective than usual, and inadequate coverage, spraying too late, or employing too volatile oils, and other seasonal factors were contributory causes.

The black cherry aphid, *Myzus cerasi* Fab., was much more troublesome in southern Ontario sweet cherry orchards than in 1940, and was unusually abundant on sour cherry trees.

The plum curculio, *Conotrachelus nenuphar* Hbst., was abundant on unsprayed plum and apple trees locally in New Brunswick and Quebec. An average infestation was reported in Ontario.

A very great reduction in the infestation of the oriental fruit moth, *Grapholitha molesta* Busck., occurred in the Niagara Peninsula, Ontario, during 1940. The first brood was parasitized more heavily than usual by the species *Macrocentrus ancylivorus* Roh., and early hardening of twig growth hindered the establishment of second brood larvae. In addition, excessive sap flow following heavy rains caused the drowning of many larvae in their tunnels. As a result, the late summer population was so reduced that injury to fruit was negligible. The infestation in southwestern Ontario was more uneven, injury being generally lower than in 1940. However, a few locally severe outbreaks were reported.

A local outbreak of the cottony peach scale, *Pulvinaria amygdali* Ckll., occurred in a peach orchard at Grimsby, in the Niagara district, Ontario, and caused conspicuous smutting of the fruit.

The cranberry fruit worm, *Mineola vaccinii* Riley, again caused considerable loss of fruit on the cranberry bogs in Nova Scotia, and along the north and eastern coastal areas of New Brunswick. The chain spotted geometer, *Cingilia catenaria* Drury, continued abundant in cranberry and blueberry barrens in New Brunswick, but declined in numbers somewhat in the western region of Nova Scotia, where it has been very numerous during the past few years.

Grape leafhoppers, *Erythroneura* spp., were again present in injurious numbers in vineyards of the Niagara Peninsula, Ont. The grape berry moth, *Polychrosis viteana* Clem., was a serious pest in the Virgil district, Ontario.

The usual reports of damage by various small fruit insects attacking currants, raspberries, and strawberries were received from different sections of the Dominion. Apparently none of the infestations were of an outstanding character.

Forest and Shade Tree Insects

A comprehensive summary concerning insects affecting forest and shade trees in Canada during 1941, prepared by Dr. A. W. A. Brown, in charge of the forest insect survey of the Division of Entomology, is issued asa departmental publication. The following statement, therefore, deals only with the more important and widespread of the pests concerned.

A notable feature of the season was the marked decline in the abundance of the European spruce sawfly, *Gilpinia hercyniae* Htg., throughout a large part of the heavily infested regions of Eastern Canada. An important factor in this reduction is natural control agencies, especially a widespread disease of the larvae, and also the activities of introduced parasites. Some increases occurred in the more lightly infested areas in the Temiskaming, Abitibi, St. Maurice and Laurentides regions, and extensions in distribution were found south of Algonquin Park, Ont., in the Gatineau Valley, and along the Mingan coast north of Anticosti Island, P. Q.

The spruce budworm, *Archips fumiferana* Clem., continued to be a major pest on balsam fir in the Algoma region of northern Ontario, and a new, heavy outbreak appeared in the northwestern section of Algonquin Park. Other smaller heavily infested areas occurrred at various points in northern Ontario, and medium to light infestations extended through southern Ontario and over much of Quebec and northwestern New Brunswick. The severe outbreak on spruce and tamarack in the Spruce Woods Reserve, Manitoba, continued, and medium infestations were discovered west of Lake Winnipeg, and also in Alberta in the Banff, Yoho, and Glacier National Parks, in the Rocky Mountain region. The biological race of this species, known as the jack pine budworm, continued to be of major importance as a forest pest in central Canada, notably in northwestern Ontario. Local severe outbreaks occurred near Fort a la Corne, Saskatchewan, and Riverton, Manitoba. There was also a moderate to severe infestation in the Spruce Woods Reserve and the Riding Mountain National Park, Manitoba. Reductions in intensity of the infestation were noted in some localities in Manitoba and northwestern Ontario. The heaviest mortality of timber so far has occurred in the Kenora district.

Bark beetles have been recorded causing damage in a number of areas extending from northwestern Ontario to British Columbia. In northwestern Ontario and Manitoba, the beetles, mostly *Ips*, are multiplying in the timber weakened by the attacks of the spruce budworm. However, losses so far are slight. In the vicinity of Banff, Alberta, there is a serious infestation of the mountain pine beetle,

Dendroctonus monticolae Hopk., in lodgepole pine, affecting an area of about thirty square miles. In British Columbia, this species has increased in the southern part of the Kootenay National Park and a considerable percentage of the lodgepole pine has been killed.

The European pine shoot moth, *Rhyacionia buoliana* Schiff., has continued to increase and spread in southern Ontario. Severe infestations are present in the St. Catharines-Niagara Falls area, and the attack is heavy at Hamilton and Toronto, and locally in Essex County. The northern distribution along the Lake Huron shore has extended to Bayfield, Huron County.

There was a general decline in the numbers of the larch sawfly, *Pristiphora erichsonii* Htg., throughout Eastern Canada. In the Maritime Provinces, at least, this was due in part to the imported parasites, *Mesoleius tenthredinis* Morley. Light to heavy infestations occurred locally in Quebec, northwestern Ontario and Manitoba. In British Columbia the species has extended its range westward to the divide separating the Arrow Lakes from the headwaters of the Kettle River. Local increases and heavy defoliation were reported in several other localities in the province.

The bronze birch borer, *Agrilus anxius* Gory, continued to be a pest of major importance in the Maritime Provinces. Throughout Cumberland and Colchester Counties, N. S., dead and dying birch were more noticeable than in 1940. Heavy attacks occurred throughout most of New Brunswick, as far east as Kent County. On Prince Edward Island there has been much damage to white birch growing in the open and in over-mature stands. The white birch was also quite heavily infested in northwestern Ontario, from Lake Nipigon west and northwest to the Manitoba border.

The beech scale, *Cryptococcus fagi* Baer., has now extended northward in New Brunswick to a point near Newcastle. The infestations range from old, severe ones along the Bay of Fundy and the coast of Northumberland Strait where most stands are infested and many trees dead, to recent infestations in the most central regions of the province, which occur in varying degrees of intensity, from light to heavy. Apparently, the species is also present from light to moderate degree in young stands of beech in Nova Scotia, where in recent years most of the mature beech has been killed. In Prince Edward Island, mature beech has also been severely damaged, and many trees are dead.

The fall cankerworm, *Alsophila pometaria* Harr., was again a serious pest on boxelder and other deciduous trees throughout the prairies, from Winnipeg westward to Lethbridge, and north to Saskatoon. Local outbreaks of this species occurred in southern Ontario, and light to medium infestations were reported locally in Nova Scotia and New Brunswick.

Reports of defoliation by the mountain ash sawfly, *Pristiphora geniculata* Htg., were received from various parts of Eastern Canada. Complete stripping of the foliage was rather general throughout southern New Brunswick. Defoliation also occurred in Nova Scotia and Prince Edward Island. The species was generally present throughout the Eastern Townships of Quebec, and was notably abundant in the Ottawa district.

An extensive outbreak of the forest tent caterpillar occurred in northern Ontario, from Island Falls west to beyond Hearst, north to Smoky Falls and as far south as Missinaibi in northern Algoma. The species was somewhat less prevalent in the Prairie Provinces than in 1940, but severe infestations occurred in a number of localities. The main area of the Western outbreak was in the Yorkton district of Saskatchewan, extending east to the Riding Mountain and Duck Mountain, Man. In eastern British Columbia, there was an extensive outbreak in the Caribou district and several thousands of square miles of poplar and willow forests were reported to have been defoliated.

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Ontario Department of Agriculture

Seventy-Third Annual Report

of the

Entomological Society

of Ontario

1942

PRINTED BY ORDER OF

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1943

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Entomological Society of Ontario

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FINANCIAL STATEMENT

For the Year Ending October 31st, 1942

Receipts

Balance on hand in Bank	$ 623.71
Dues	241.93
Subscriptions	434.36
Advertising	304.95
Back Numbers	46.80
Bank Interest & Exchange	23.17
Government Grant	300.00
Miscellaneous	1.03
	$1,975.95

Expenditures

Printing Canadian Entomologist	$ 992.00
Reprinting Canadian Entomologist	122.00
Postage	43.16
Bank Enchange	2.81
Honoraria & Stenographic Assistance	255.00
Annual Meeting	3.15
Miscellaneous	26.91
Balance on hand in Bank	530.92
	$1,975.95

Audited and found correct
L. Caesar
H. W. Goble
Auditors

Respectfully submitted

A. W. Baker
Secretary-Treasurer

Entomological Society of Ontario

REPORT OF THE COUNCIL 1941-1942

The seventy-eighth annual meeting of the Society was held in the auditorium of the Royal Ontario Museum, Toronto, on Thursday and Friday, December 11th and 12th. The meeting of the Council was held in the offices of the Plant Inspection Division, 21 Lombard St., Toronto. During the course of the meetings, at which thirty papers were presented, fifty-three members and visitors were registered.

We record with sorrow the deaths of Mr. A. K. Gibson, member of the Society, Mr. J. K. Jacob of the B. C. Society, and Mr. A. A. Dennys, who at various times have been associated with the work of the Society.

The Council is honoured in expressing appreciation of the services which are being rendered by those members of the Society who are on active service with His Majesty's forces. It is the hope of the Council that they may be spared to soon return to active entomological work.

The journal of the Society, the Canadian Entomologist, completed its seventy-third volume in December, 1941. This volume of 236 pages illustrated by 18 plates and 59 figures contained 52 articles, 10 book notices and 17 notes.

These articles were contributed by fifty-one authors including writers in six provinces of the Dominion and twelve states of the Union.

RECORD OF PAPERS PRESENTED AT THE SEVENTY-NINTH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, AT OTTAWA, NOVEMBER 12, AND AT GUELPH, ONT., DECEMBER 4, 1942.

"Collecting at Hudson Heights, 1941 and 1942"—G. A. Moore.

"Some remarks on Aerosols"—H. A. U. Monro.

"The European Corn Borer situation in Ontario in 1942"—R. W. Thompson.

"The control of pediculosis and scabies by means of preparations containing pyrethrins, rotenone and aliphatic thiocyanates"—C. R. Twinn and C. G. MacNay.

"The value of molasses-free baits in the control of cutworms in tobacco fields"—D. A. Arnott and G. M. Stirrett.

"Stored products pests during 1942 in relation to food conservation"—H. E. Gray.

"Entomology in Canada since the outbreak of war"—L. S. McLaine.

"Insects as landscape artists"—J. J. DeGryse.

"The entomologist in relation to the military services in the United States of America" —S. A. Rowher.

"The status of the Japanese Beetle in Ontario"—W. N. Keenan.

"Analyses of laboratory tests of insecticides as illustrated by results in experiments with *Drosophila melanogaster* and *Myzus persicae* carried by C. W. Maxwell"—G. Beall.

"Studies on larvae of the genus *Melanolophia* (Lepidoptera, Geometridae)"—W. C. McGuffin.

"The problem of insecticide supply"—A. M. W. Carter.

"Artificial establishment of a sawfly disease in Western Quebec"—C. E. Atwood.

"Notes on the genus *Cinara* (Hemiptera Aphidae)"—G. A. Bradley.

"The work at the parasite laboratory, Belleville, in relation to the war effort"—A. B. Baird.

"Recent developments in the Corn Borer parasite situation"—Geo. Wishart.

"Control of stored grain insects under farm conditions"—H. W. Goble.

"The distribution of the eggs of *Encarsia formosa* Gahan, with respect to its host."—Thos. Burnett.

"The Lesser Peach Borer"—T. Armstrong.

"The place of professional biologists in the armed forces"—A. W. Baker.

"The Japanese Beetle on the Niagara Frontier"—R. W. Sheppard.

"Chrysanthemum Midge control"—G. G. Dustan.

"Parasites of grasshoppers with notes on their larval stages"—R. W. Smith.

"The relation of some apple sprays to parasitism of the Codling Moth by *Ascogaster quadridentatus* Wesm."—H. R. Boyce.

"Availability of insecticides and use of substitutes"—W. A. Ross and R. W. Thompson.

THE WAR ACTIVITIES OF THE FEDERAL DIVISIONS OF ENTOMOLOGY AND PLANT PROTECTION SINCE 1939*

By L. S. McLaine**

Division of Entomology, Science Service,

Department of Agriculture, Ottawa, Ont.

This paper is largely confined to insect investigations and control activities relating directly to the war, and carried out since its outbreak in September, 1939. Consideration is not given to the general work of the Divisions or to the increasingly close and effective cooperative activities with the United States Bureau of Entomology and Plant Quarantine, various state organizations, and provincial departments.

Research Projects and Publicity

Since the war began the research projects carried out by officers of Division of Entomology from laboratories and field stations across the Dominion have been carefully reviewed. Many of the less important ones were dropped for the duration of the war and emphasis has been shifted to major projects having a direct and important bearing on the war effort.

Increased attention has been given to disseminating information and direction to agricultural producers and others through the medium of the radio, the press, public addresses, and mimeographed and printed publications, including a series of special pamphlets known as the "War-Time Production Series", issued through the Agricultural Supplies Board. Advice of interest to householders and the food products industry is distributed in a similar manner, and assistance is given on insect control problems to Government agencies, the armed forces, and the war production industry generally.

Stored Product Insect Problems During the War

Grains and Cereal Products:

To maintain in good condition the large stores of wheat and other cereal products now on hand in Canada has imposed a very heavy load on Canadian services and facilities. In peacetime the orderly marketing of commodities permitted regular and systematic cleaning of storage facilities, a measure which aids greatly in reducing insect attack. With the fall of France, Belgium, Holland and Norway, the market outlets for Canadian wheat were greatly reduced and we have been faced with an ever-increasing carry-over. When it is considered that the 1941 crop was a heavy one, and that of 1942 the largest in our history, the magnitude of the task is apparent.

Present storage facilities are not sufficient to house all the grain now on hand and to be threshed during the current crop year. It is probably a conservative estimate that at least 250,000,000 bushels of wheat and coarse grains will

*The material on which this article is based was brought together through the cooperation of officers of the Divisions of Entomology and Plant Protection, of the Science Service.

**Dominion Entomologist and Asst. Director of Science Service.

Contribution No. 2206, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

have to remain exposed to the weather or be housed in shelters built in the future.

The storage of food products in large quantities for long periods of time is always accompanied by serious insect problems. In Canada the first insect problem since the outbreak of war was the infestation, in 1940, of a terminal elevator by the Indian meal moth and *Ephestia* species. The insects caused appreciable damage to the grain on the surface of the bins. Control was effected by fumigation with HCN in the form of discoids, followed by treatment with "Weevil-Cide" to kill the larvae deeper in the bin. A pyrethrum spray was used on the bin floor and around the ventilators and belts.

During the winter of 1940-41 a large scale outbreak of grain mites occurred principally in the temporary storages erected at country points by the various grain companies to provide additional storage space. The seriousness of the situation was greatly increased by the failure to provide ventilation. As a consequence, considerable condensation occurred near the upper surface of the grain and the resulting moisture was absorbed by the wheat and an ideal environment for the rapid increase of mites was created.

Research work demonstrated that grain mites, principally the common grain mite, *Acarus siro* L., could be controlled by fumigation with chloropicrin. This material was injected somewhat below the surface at a rate of about one-half of that recommended for the control of stored product insects and has given satisfactory control. The cost of fumigating a 30,000 bushel storage in this manner averaged about thirty-five to forty dollars.

Another problem has arisen more recently not only in country temporary storages but also in the large storages at the Head of the Lakes. This is the infestation by the rust-red grain beetle and psocids, of grain of low moisture content. While all the grain was cleaned prior to loading, infestations have occurred within a period of six months after binning. The temperature of the grain was raised in some cases to about 100°F. While the presence of moisture greatly aids the build-up of these populations, once the cycle has started the insects may frequently be found in prodigious numbers in grain which contains about 12.5% moisture. Fumigation has aided in control although, in some cases, moving the grain has been necessary. The task of adequately sampling a storage bin, which is several acres in extent, to determine whether it is infested, is a big problem in itself.

Spider beetles have caused considerable losses in flour warehouses during the past two seasons in Western Canada. Meetings were held with milling company representatives in March and April, 1942, and a large scale control campaign organized. A survey during June of the areas involved, indicates that control measures have been very well carried out and losses are much lower than in 1941. These insects are also potentially serious pests of grain in storage and efforts have been made to prevent their establishment in grain annexes.

The transportation of insects by railroad cars is a serious problem where grain must be maintained in storage for long periods of time. A system is now in effect whereby the cars which carry grain known to contain any insect-infested material are thoroughly cleaned by means of compressed air by the receiving terminal elevator before the car is returned to the railroad company.

Probably the greatest aid in dealing with grain insect problems is a clearing house for information on the entomological problems of the grain trade, established in Winnipeg. Through the co-operation of the Board of Grain Commis-

sioners and the Division of Entomology an officer is devoting his full time to the problems which arise in this connection. Another officer is taking care of grain storage problems at the Head of the Lakes.

While the task is not an easy one, serious losses have been avoided so far. The silver lining in the situation is the knowledge that most of these troubles will solve themselves when peace is established and normal trade in grain is resumed.

Dried Apples and Dehydrated Vegetables

Since the beginning of 1941 a steady increase in the production of dried apples and dehydrated vegetables has taken place in this country. This has been caused by an increase in home consumption and export to the United Kingdom, and has resulted in an increase in the number of plants operating, and the expansion of plants already in operation.

This type of food product is readily infested by insects, particularly the Indian meal moth. The Divisions of Entomology and Plant Protection, and the Marketing Division of the Fruit Branch have given particular attention to the protection of these prepared foods. This has entailed the inspection of all plants and warehouses concerned. Regulatory steps were taken, and in certain cases the plants were shut down until conditions were satisfactory. In general the owners and managers of the plants co-operated readily and endeavoured to improve conditions and to put into effect measures to prevent infestation.

The matter of packing the product has been considered and recommendations have been made to improve the containers, particularly those for dried apples. In the past, the containers for dried apples consisted of wooden cases with open spaces between the boards, which provided easy access to insects. The new container under consideration is of the carton type with a sealed lid. It is hoped that this will prevent insect invasion and prove satisfactory from the shippers' point of view.

Disinfestation of Imported Foodstuffs, Ships and other Carriers

The importance of problems arising from stored product insect infestations has been forcibly impressed upon us by experiences in the field of shipping and transportation. For the most part the trouble has arisen in connection with boats which carry, or have recently carried, tropical products from the Orient. The serious delays and long voyages on the high seas necessitated by war have allowed serious outbreaks of insect pests to occur in cargoes which may have been but lightly infested at the time of original shipment. Apart from the necessity of controlling outbreaks in the products themselves with the object of preventing further wastage of valuable foods, there is the serious situation brought about by the contamination of other foods and commodities which come in contact with the infestation in steamship sheds, railroad cars, lake and canal steamers, trucks, and terminal warehouses. In this connection special emphasis has been laid on the prevention of contamination of foods destined for Great Britain.

Infested Tropical Cargoes

To give an example: in the summer of 1941 a steamer arrived at one of the Eastern Canadian ports with a cargo consisting almost entirely of nuts, mainly peanuts and shelled walnuts. These were heavily infested with a number of insects principally the red flour beetle and the saw-toothed grain beetle. In this instance, no action was taken to treat the cargo as a whole, although much of the cargo was treated by vault fumigation at the request of individual importers.

The balance of the cargo was forwarded without treatment in a number of lake steamers, and by rail. The infestation immediately contaminated everything brought in contact with the shipments, and led to numerous complaints received from every part of the country, very often in connection with material upon which the insect could not feed, but which they were overrunning in great numbers.

Fumigation in Railroad Cars

As a result of the above and related experiences prompt action is now taken with a view to preventing the spread of such infestations. For instance a cargo of infested nuts which arrived this summer was inspected immediately the vessel arrived in port and, in view of the infestation found, was held under restriction pending satisfactory treatment. In order to avoid congestion at the port of entry, the nuts were allowed to proceed in refrigerator cars or steel box cars in first class condition direct to three cities, where facilities existed for rapid treatment with a minimum of delay. The importers were allowed the option of (*a*) fumigation in the railroad car, or (*b*) fumigation in a vault with treatment of the railroad car after unloading, all to the satisfaction of the Department. As the first method is the most convenient and least expensive it was adopted in the majority of cases, the work being done mainly by pest control operators under supervision. It was found that the Canadian steel box cars were in excellent condition and, when carefully sealed, proved ideal for fumigation. Excellent kills were obtained, which served the double purpose of preventing spread and disinfecting the railroad car.

With these treatments it was found possible to deal with a large cargo of nuts, made up of 75,000 bags of peanuts, 10,000 cases of shelled walnuts, and 3,000 bags of walnuts in the shell, in all about 250 carloads.

Other Treatments

The success of the railroad car fumigation has led to the concentration mainly on this method, although other methods could be used. Tarpaulin fumigation could be employed for small shipments, and small canal boats or barges could possibly be used, although neither of these methods has been tried by this Service yet.

It will be realized that an attempt to fumigate a whole boatload of foodstuffs on arrival would be beset by many difficulties and complicating factors, the most important being the necessity of immediately unloading the vessel, owing to the shortage of ocean-going ships.

On one occasion a steamer loaded with grain for Great Britain suffered damage in a storm at sea and some sea water entered the holds. It was over four months before the ship unloaded the cargo and was placed in dry dock. On opening the hatches to take the grain into an elevator a heavy infestation of the rust-red grain beetle, *Laemophloeus ferrugineus* Steph., was discovered, necessitating the treatment of 300,000 bushels of grain on the belt as it entered the bin.

In cases where infested cargoes have lain in elevators or in steamship sheds, the latter have been cleaned or sprayed under supervision after the removal of the goods.

Cleaning of Steamships

As part of the policy of protecting from insect infestation all foods consigned to Great Britain, all boats to be loaded with grain or cereal products destined for

that country have been regularly inspected, when empty. When infestations of insects have been found in the empty holds which might be liable to contaminate the cargo, and lead to subsequent outbreaks in the goods when stored on the other side, we have required that thorough physical cleaning and chemical treatment be carried out in the cargo space to the satisfaction of our officers. The treatment has usually consisted of spraying with pyrethrum-kerosene spray. By this method the loading of the boat is not greatly delayed. As soon as one hold is sprayed, and passed by the inspectors, loading can begin. In cases where the authorities of the medical quarantine have called for fumigation of the empty boats to control rats, the dosage of hydrocyanic acid gas has been increased to eight ounces per 1000 cubic feet for an exposure of 12 hours, with satisfactory control of a number of the more common stored product insect pests in the hold.

Medical and Veterinary Entomology

Biting Fly Repellents

During the spring and summer of 1942 further study was given to the subject of developing improved repellents for use against biting flies attacking humans. Effective and persistent repellent mixtures that have no ill effects on the user are greatly needed for the protection of the personnel of the armed forces stationed or operating in areas where blood-sucking flies are numerous, as well as for civilian use. Several hundreds of tests were made of more than a score of promising mixtures. These tests were carried out chiefly against mosquitoes of the genus *Aedes* under natural conditions at selected points in Quebec, Ontario and British Columbia, and in accordance with a definite procedure adopted to secure as much data as possible of use in evaluating the mixtures on a comparable basis. The results so far have been very encouraging, several of the mixtures proving definitely superior to preparations previously in popular use.

Human Lice and Scabies

The problem of controlling human lice and scabies is a particularly serious one under war conditions. During the last World War, louse-borne diseases and the skin infection caused by *Sarcoptes scabiei* were fruitful sources of casualties in the contending armies. Since that time several new insecticides showing promise as pediculicides and acaricides have been developed. Among these are the aliphatic thiocyanates and rotenone-bearing roots such as derris and cube. Pyrethrum extracts, also, have been greatly improved and standardized. During the past two years tests have been made which show that any one of these three insecticides, incorporated with carrier materials in the form of lotions and ointments, is very effective against lice and scabies. The tests on head lice were carried out on Ottawa school children during 1941 with the co-operation of the local health authorities. Experiments on crab or pubic lice, and scabies were made with the co-operation of medical officers of the Royal Canadian Army Medical Corps, on infested soldiers in two military camps in Ontario, during 1941 and 1942.

Tick Repellent Studies

Tick paralysis is a seasonal disease in Alberta and British Columbia, where it annually takes toll of cattle, sheep and rarely horses. It is caused by the so-called Rocky Mountain spotted fever or paralysis tick which is common in those provinces. To date no adequate treatment for the protection of livestock has been evolved. Extensive, though so far unsuccessful, experiments have been

carried out to develop a spray, or dip, that will be practical in protecting these animals from ticks.

Spotted Fever and Plague Surveys

Annually for five years surveys of ticks and rodents and their external parasites have been carried out in British Columbia to determine the presence of Rocky Mountain spotted fever and bubonic plague. This is a British Columbia Department of Health survey organized and supervised by officers of the Division of Entomology and the Dominion Department of Health. The surveys in the spring were devoted to tick collections, the ticks being tested for spotted fever. Plague work in the summer and fall consisted of the collection and autopsy of ground squirrels and rats and testing of their fleas. Ticks positive for spotted fever have been collected at a few points but no positive plague specimens have been taken in British Columbia.

Warble Fly Programme

Losses in leather, beef and dairy products due to cattle warbles are especially important during time of war. With the co-operation of provincial authorities plans are under way to reduce such losses. Improved methods of control are being investigated.

Field Crop and Garden Insects

Grasshopper Control

In the Prairie Provinces, where severe grasshopper outbreaks occur periodically, our officers are continuing ecological and control studies on a reduced bases necessitated by a curtailment of personnel and travelling facilities due to war conditions. Since the war began special emphasis has been placed on poisoned bait investigations. The purpose of this study is to test substitutes for sodium arsenite and other ingredients, and to reduce the cost of materials and haulage, storage and labour, and to prolong the effectiveness of the bait.

Wheat Stem Sawfly

During recent years the wheat stem sawfly has been the most serious pest of grain crops in Alberta and Saskatchewan, and, in 1941, caused a loss estimated at not less than fifty million bushels of wheat. Investigations to improve control methods are being continued. Extension work to instruct farmers is carried on in co-operation with provincial officials and the Dominion Experimental Farms Service. The value of flax in clearing land of sawfly infestations has been emphasized and was an important influence in increasing the acreage of flax in many areas.

Calcium Arsenite in Potato Beetle and Grasshopper Control

In view of a threatened shortage of sodium arsenite and standard potato beetle insecticides, studies were made of the value of calcium arsenite and its effect on potato foliage. It was found to be effective against the beetles and harmless to foliage when used at the rate of ½ pound per 40 gallons of water. It was also demonstrated to be an effective ingredient in poisoned bran-sawdust baits for grasshopper control. However, nearly three times as much of this poison is required than when using sodium arsenite.

Cabbage Maggot Control

Corrosive sublimate has been widely used in the control of cabbage maggots for many years. The war has reduced available supplies of this chemical. Studies

of substitutes showed that a dust of one per cent. creosote with clay is effective, practical and cheap. However, although equal to calomel dust it is not as good as standard corrosive sublimate.

Seed Crops in British Columbia

The production of vegetable seeds has increased enormously in British Columbia under war conditions, and our officers have given increased attention to the control of insects attacking the seed crops. Fortunately, with the exception of the parsnip webworm which attacks parsnip seed, seed production has suffered little interference from insect pests, and losses have been slight.

Fruit Insects

Studies of insects affecting fruit and the improvement of insecticides and spraying practices are carried on from laboratories in Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia.

Essentially, the object of this work during the war is the same as it is under normal conditions, namely, to assist the fruit-growing industry by a more or less balanced programme of investigation and extension in producing the maximum amount of food in the form of marketable fruit with the least possible labour and expense.

Apart from creating a shortage of farm labour, the war has not injuriously affected the economic position of growers of small fruits, grapes, stone fruits and pears. Consequently, they have been financially in a position to carry on any control programme necessary for the protection of their crops. The situation in the apple-growing industry, however, has been quite different. Here, due to the war, and the lack of shipping, the overseas market on which a goodly portion of the industry was dependent has largely disappeared. This has resulted in marketing problems which would likely have been still more serious if there had been bumper crops throughout the Dominion. Lower prices for apples and the unfavourable outlook for the industry have made some pest control problems more acute, since many growers have failed to give their orchards the same care as in the past, and others have discontinued control operations entirely. Consequently, entomologists have been called on to check their control recommendations very carefully and to work out more economical control programmes.

Forest Insects

The function of the forest entomologist of the Division is to protect the forest and its products from insect injury. This is especially important in time of war in view of the present unprecedented demand for lumber, paper and other forest products. Since the outbreak of war, work has been concentrated on those projects which have a bearing on the production of war materials, including lumber for construction, boxes and crates; veneer and plywood for aircraft; paper, fibre-board, and explosives. The demand for these materials is of such magnitude that nearly all merchantable timber species in Canada are being exploited, from the Douglas fir in British Columbia, to the yellow birch in the Maritime Provinces. The forest entomologist is assisting in maintaining and improving methods of detection, prevention and control of insect infestations and damage, and directing the salvage of injured stands.

The Spruce Budworm

At the present time, balsam fir and white spruce over an area of some 40,000 square miles in western Ontario have been severely damaged by the spruce budworm. The control of this outbreak and salvage of the enormous amount of

timber involved is a problem of great magnitude. The outbreak has been brought to the attention of the operators and specific recommendations have been made for utilization based on data obtained from sample plot studies and from intensive surveys. Reports have been prepared and sent to all parties concerned, on the extent and progress of the outbreak and on the prospects for the ensuing year. It is encouraging that salvage campaigns are well under way in many of the heavily infested districts.

A somewhat similar condition occurs in Manitoba and northwestern Ontario where huge areas of jack pine have been attacked by the jack pine budworm. The entomologists have been called upon to provide information on the extent of the infestation and the degree of mortality so that the operators and provincial governments are kept informed of the situation and can make plans for salvaging the dead and dying timber before deterioration renders the wood unmerchantable.

The Bronze Birch Borer

In recent years, our officers have been studying a serious outbreak of the bronze birch borer in yellow birch in New Brunswick. The dead and dying trees deteriorate rapidly and become totally unfit for high grade lumber or veneer. The demand for good quality birch veneer has increased enormously due to the requirements of the aircraft industry, but only a small percentage of the trees are of the proper size and quality for plywood. Steps were taken to discover the extent and importance of the damage; extensive surveys and examinations were made and attention was drawn to the injury before many owners of birch were aware of it. Full information on the degree of attack has been made available to the operators and to the Provincial Governments with the result that cutting operations have been planned and put into effect in those areas where the birch is still merchantable, but which are likely to become attacked in the near future. Recommendations have also been made for the maintenance of vigorous stands of birch by the removal of decadent trees, harvesting at maturity, and by other methods of forest management.

Salvage of Fire-killed Timber

Another problem of vital importance is the salvage of fire-killed timber before it becomes riddled by wood-borers. Forest entomologists have inspected extensive areas of burnt timber in Manitoba, Saskatchewan, Ontario and Quebec and have provided the operators and provincial forest services with information on the degree of borer damage. Salvage campaigns have been carried on during the summer months in stands which are definitely subject to injury. In some areas, however, damage by wood-borers was slight due to the severity of the fire, and salvaging of the logs could be delayed until the winter without much loss through deterioration. The degree of wood-borer injury to fire-killed timber depends on several factors such as the severity of the fire, time of year when burned, and the species of trees involved; all these factors must be considered when making an appraisal of damaged stands.

Forest Insect Survey

The detection of insect outbreaks, whether incipient or well established, is considered to be an essential form of forest protection. A forest insect survey was commenced in 1936 with the object of obtaining detailed information on forest insects throughout the Dominion. This project has been continued during the three years of war and has also been enlarged in scope in order to ensure the timely discovery of new outbreaks of native or introduced forest pests. The

survey is the only means of obtaining information on insect outbreaks and relaying it to the lumber and paper companies and the provincial forest services.

Ambrosia Beetles

In the Pacific coastal region, damage is caused to freshly cut logs by ambrosia beetles. Although the loss is typically one of quality rather than of volume, these beetles are responsible for the degrading of a considerable quantity of sapwood lumber. The problem of protecting logs against ambrosia beetle attack is therefore of some importance and studies are being made in an effort to devise economically sound methods of protection.

The Biological Control of Insects

Under present conditions when manpower, equipment and chemicals are urgently required in the active prosecution of the war, special efforts are being made to utilize insect parasites, predators, and other natural control factors as much as possible in controlling destructive insect pests. This work is centred at the Dominion Parasite Laboratory, Belleville, Ont., where special staff and equipment is maintained for research and large scale propagation projects.

Several projects initiated prior to the war have been producing important results in the protection and conservation of resources. The European larch sawfly, a most destructive enemy of larch in Canada, has been reduced and held in check in many areas by the distribution of the introduced parasite *Mesoleius tenthredinus*. The European spruce sawfly, which a few years ago was seriously threatening the spruce forests of Eastern Canada, has been reduced in numbers by the distribution of nearly 900 million parasites and these, together with weather, disease and other factors, have greatly delayed, if not completely prevented, their wholesale destruction. Incipient outbreaks of three European pine sawflies have also been reduced by timely parasite liberations.

The greenhouse industry has received material assistance from parasite which control white fly and mealy bugs. Between one and two million parasite of these pests have been sent out from Belleville each year. The parasites of greenhouse thrips, aphids and other insect pests are being investigated with a view to giving similar assistance.

The Imperial Parasite Service, which for many years was located at Farnham Royal, England, was transferred to Canada in July, 1940. With headquarters at the Dominion Parasite Laboratory, Belleville, Ont., its valuable service to all parts of the Empire has been continued. The Canadian organization is co-operating as much as possible in this emergency war effort. During the present year an exchange of parasite material between England and Canada was arranged, among which were parasites of white grubs.

The Canadian Insect Pest Survey

The work of collecting, organizing, and interpreting data on the distribution and economic importance of insect pests in Canada has been continued on a modest scale during the war years. This service is perennially important, but assumes increased significance in wartime, in connection with the need of keeping investigators and others concerned with the prompt application of control measures in touch with developments in the insect pest situation.

Pesticides Committee

Shortly after the outbreak of war a Pesticides Supply Committee was set up in the Department of Agriculture at Ottawa, to take care of the supply and

distribution of pesticides under war conditions. The work of this committee has now largely been superseded by the recently appointed Pesticides Administrator.

Insecticide Information Service

As a result of war conditions supplies of various insecticide materials have become uncertain and, in some important instances, definite shortages have developed. To prevent, as far as possible, the serious effects that might result from this state of affairs on the control of injurious insects, an insecticide information service to Dominion and Provincial officials has been developed. Through this service, officials concerned with pest control are promptly informed of actual and potential shortages of insecticides and the availability and suitability of possible substitutes.

Registration of Insecticides

Under the Pest Control Products Act of 1939, all pest control products sold or offered for sale in Canada must be registered in accordance with the provisions and regulations of that Act. The administration and enforcement of the Act is in the hands of the Plant Products Division of the Department of Agriculture, but all applications for registration are submitted to specialists in the Science Service for approval before being accepted or rejected. Many hundreds of such applications have been critically examined by officers of the Division of Entomology during the past three years, and their recommendations and suggestions have been passed on to the insecticide industry. This has resulted in a marked improvement not only in the quality and effectiveness of the products, but also in the claims and directions that accompany them, greatly to the benefit of the consumer. Moreover, it has been possible to assist the industry in modifying or changing the formulae of their products when such has been necessary to meet shortages of certain insecticides resulting from war conditions.

OBSERVATIONS ON THE NUMBERS AND SPECIES OF BUMBLE BEES VISITING RED CLOVER

By F. O. Morrison, *Macdonald College, P. Que.*

Purpose of the Observations,—The Department of Agronomy at Macdonald College has for some years studied the problem of seed set in red clover as related to the date of bloom. To this end replicated plots of clover are cut on different dates each year to ensure continuous bloom throughout the summer. In 1939, the Department of Entomology was asked to cooperate in this work by making a survey of the species of bumblebees visiting these plots and the number of visits, with the object of throwing some light on the controversy started by Darwin when he credited bumblebees with the whole job of the pollination of this species of plant. The data presented here were accumulated during this survey.

Procedure,—The procedure decided on was first to collect local bumblebees widely, determine the species, and learn to recognize them in the field. Visits were made to the flowering plots of clover, twice a day on three days of each week. When weather permitted alternate days were chosen. The visits were carried out at 11 A.M. and 4 P.M. of each day and lasted twenty minutes. During that time the observer walked about the plots, following a definite pattern, and

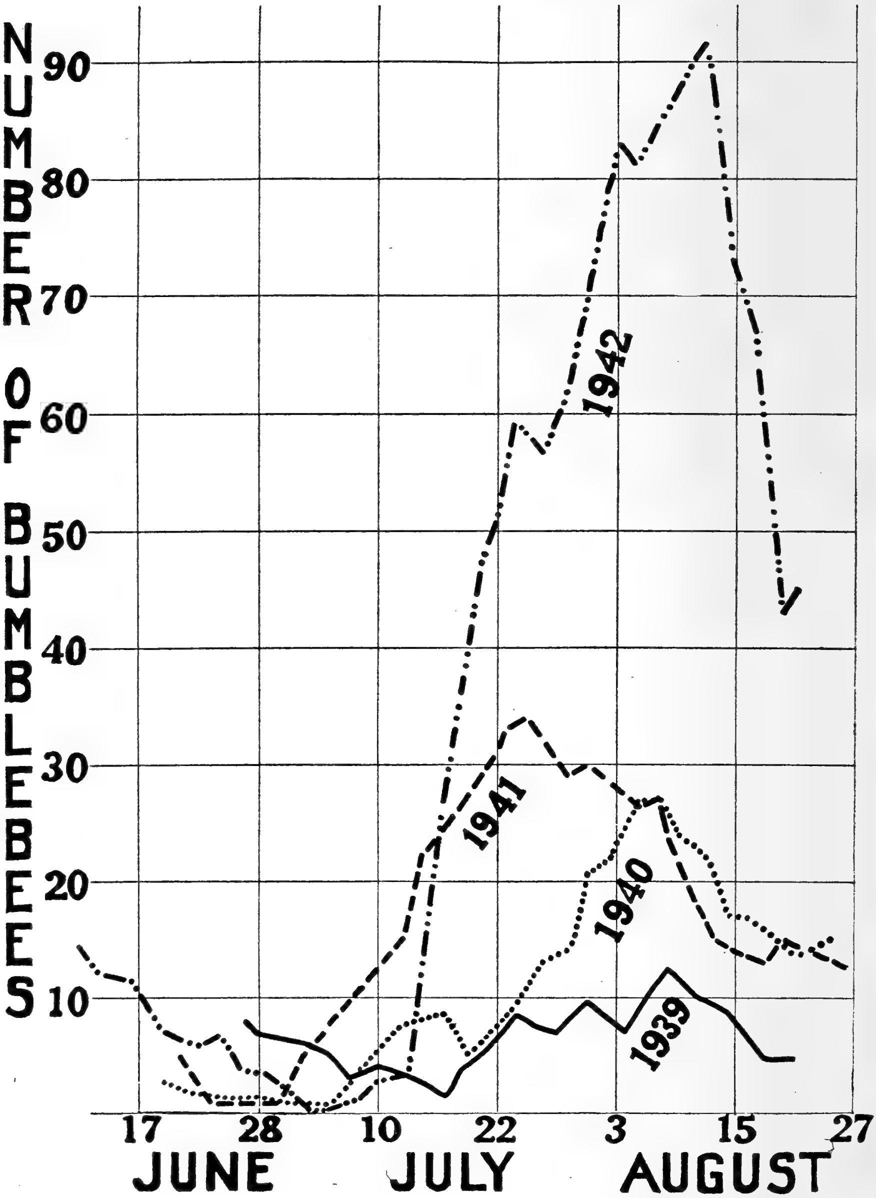
noted each visiting bumblebee and its identity. The numbers observed varied somewhat widely from day to day, due to local weather conditions, so that when these were later graphed the line was very irregular and any trend was hard to follow. A common statistical trick was resorted to, to smooth out the line. Each three successive observations were added, and averaged, the average being credited to the date of the middle observation. Thus observations made on June 10, 12 and 14 were averaged and credited to June 12, while those of June 12, 14 and 16 were averaged and credited to June 14.

NUMBERS OF BUMBLEBEES AND HONEYBEES OBSERVED VISITING RED CLOVER DURING THE SUMMERS 1939-42. THE TOTALS OBSERVED DURING 68 OBSERVATION PERIODS ARE LISTED FOR EACH SPECIES.

Species	*1939*	*1940*	*1941*	*1942*
Bombus fervidus Fabricius	111	178	292	647
B. borealis Kirby	3	77	27	262
B. vagans Smith	0	13	17	38
B. impatiens Cresson	13	1	12	88
B. rufocinctus Cresson	7	10	1	0
B. separatus Cresson	1	0	6	9
B. perplexus Cresson	0	6	9	3
B. ternarius Say	0	1	2	1
B. couperi Cresson	0	0	1	9
B. pennsylvanicus DeGeer	0	0	0	46
B. terricola Kirby	0	0	0	10
Apis melifica Linneus	0	59	19	256

Bumblebee Species,—Plath (2) lists thirteen species of the genus *Bombus* as common North American forms. We are not interested in the parasitic genus *Psithyrus*. The keys published by Franklin (1) include most of Plath's list and a few more. Altogether eleven distinct species were observed visiting red clover at the College. It was not found difficult to prepare a field key as two species only (*B.ternarius* Say and *B.rufocinctus* Cresson) bear orange markings. The former species has a bright orange band across the abdomen between anterior and posterior yellow bands, while the latter has a more diffuse dark orange band often divided into three bands and shows no yellow on the abdominal dorsum. The remaining species are black and yellow. Four species have the thorax all yellow dorsally. Of these *B.impatiens* Cresson has a bright yellow band, distinctly notched centrally, on the first two abdominal tergites; *B.vagans* Smith has a similar band but with the posterior edge straight, not notched; *B.separatus* Cresson has some brown pile among the yellow on the second abdominal segment; while *B.perplexus* Cresson has distinctly "dull" colored yellow pile on the base of the abdomen. The five remaining species have black and yellow on the thoracic dorsum. Two species (*B.terricola* Kirby and *B.pennsylvanicus* DeGeer) have yellow anteriorly and black posteriorly on the thorax. The former is a short, stout species with the yellow on the abdomen much deeper while the latter is an elongate species with light "canary" yellow pile. A black inter-alary band, preceded and followed by yellow bands, marks the other three species. *B.fervidus* Fabricius has "canary" colored pile over most of the elongate abdomen; *B.borealis* Kirby has a distinctly darker yellow pile; while the species which the writer takes to be *B.couperi* Cresson is smaller, short, greyish yellow and "ragged" in appearance.

It seems likely that most of the species involved are important pollinators though Plath states, "The short tongues species such as *B.affinias* and *B.terricola*


NUMBER OF BUMBLEBEES
90
80
70
60
50
40
30
20
10
1942
1941
1940
1939
17
28
10
22
3
15
27
JUNE
JULY
AUGUST

are unable to obtain nectar of long tubed flowers in the normal manner but they overcome this difficulty by biting a hole near the base of the flower".

The total numbers of bees of each species observed each year during 68 observation periods are shown in the table. At first glance it is obvious that *B.fervidus* is the most frequent visitor during all years and would thus appear to be the important pollinator. The variation from year to year, especially the regular yearly increase in numbers is striking. Plath lists this species along with *B.vagans* and *B.impatiens* as forms which produce their young queens and males late in the season and hence liable to destruction by excessive wet weather during the first two weeks in August, before the sexual castes are produced. These weather factors during the previous year may thus influence the population of the succeeding year.

Probably only in the case of *B.fervidus* are our figures largely functions of the number of bees in existence since all the figures are affected by preference for clover on which flower alone observations are carried out. Casual observations of other flowers indicated *B.ternarius* and *B.rufocinctus* to be much more numerous than indicated by these figures.

When the total numbers observed at various dates are graphed (Figure) each curve shows a minor peak in early or mid-June followed by a very low trough between June 20 and July 16, and a much higher peak in late July or early August. The early peak is caused by numbers of queens foraging to stock their nests. The trough occurs during the incubating of the early brood. After early July queens are rare and workers increase greatly in numbers to bring about the second peak.

Incidentally, record was kept of the numbers of honeybees observed collecting pollen from red clover. (It is generally accepted that only on rare occasions can honeybees reach the nectar in these flowers). The honeybee activity was limited to a short period during July and August. The visits were short and erratic. The greatest numbers were observed in 1942.

In 1940, an attempt was made to record the length of time each bumblebee spent during a visit to the plots and thus secure a unit of activity called a "bee-minute". As the graph of "bee-minutes" closely approximated that based on bee-numbers, the practice was not continued.

Seasonal Prevalence,—It has already been noted that the graph of total bees against date shows a major seasonal peak when the workers appear in the late summer. In 1939, this peak came on August 9; in 1940, about August 7; in 1941, about July 24; and in 1942, about August 12. The regularity of the curves showing the two seasonal peaks is very striking.

Yearly Prevalence,—A still more striking feature of the data lies in the wide variations of numbers annually. It may have been influenced by such facts as the position of the plots, (which varied from year to year), and the observations being carried out by different workers. Observations in 1939 and 1940 were conducted by Mr. Duncan MacDonald, those in 1941 by Mr. L. L. Kerr, and those in 1942 by Mr. Bird, Mr. Whitehead and the writer. It is interesting to note that although three observers followed each other during the different parts of the season of 1942, the trend of the curve was not disturbed.

Discussion and Conclusions,—There can be little discussion other than speculation as to the causes of the yearly variation. There would almost appear to

be a cyclic trend, but this can only be established with data from many more years. Practical interest naturally lies in how the seasonal and yearly prevalence may have affected seed production in the clover. It can only be said here that on the face of it, at least, bumblebee prevalence seems to be related to seed set both seasonally and annually. The actual figures on seed set and their interpretation, will be published as a separate paper by the Agronomy Department during this winter.

Acknowledgments,—It is desired to acknowledge the assistance of Mr. J. N. Bird of the Agronomy Department and of the various men who carried out the observations during the summers.

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THE JAPANESE BEETLE ON THE NIAGARA FRONTIER*

(A Short History of Discovery and Captures, 1940-42)

By R. W. Sheppard

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On Sunday afternoon, August 11, 1940, R. V. Featherston of the Niagara staff, Division of Plant Protection, saw a Japanese beetle feeding upon a red rose flower in the Rose Garden of Queen Victoria Park at Niagara Falls, Ontario. The beetle was promptly collected, and further search that afternoon produced three more specimens from red and pink roses.

Following this outstanding discovery, the first known hand taken collection of Japanese beetles to be made in the field in Canada, and what may be said to be the culmination of years of careful search and watchfulness along the Niagara River border, the above named officer, and the writer, proceeded the next day to the scene of the previous day's catch, and took nine more beetles, all from rose plants; eight on flowers, and one on a leaf. Between August 11 and September 23, with some intervals of cool, wet weather toward the end of August, and again in mid-September, when no beetles were taken, a total of 32 Japanese beetles, 14 males and 18 females, were collected by R. V. Featherston, F. W. Gregory, and the writer, from white, pink, and red roses, and white dahlia flowers, all within the Rose Garden area of Queen Victoria Park.

In the year 1941, following a spring application of arsenate of lead to 10 or more acres of lawns and flower beds surrounding the original point of discovery in 1940, traps were placed, by midsummer, in several large groupings throughout Queen Victoria Park, and at various other points on Niagara Park Commission land; as well as in a number of more or less adjacent private residential properties within the city of Niagara Falls.

During the period July 20 to September 22, 1941, a combined total of 64 Japanese beetles were taken in traps, or hand collected from flower-heads, only two of which, a male and a female, were trapped within the city of Niagara Falls.

*Contribution No. 31, Plant Protection Division, Department of Agriculture, Ottawa.

The remainder, 30 males and 32 females, all being obtained in Queen Victoria Park, and of these 47 were secured by trapping, and 15 by the scouting or hand collecting method. The flowering plants from which this latter group was obtained, included red, pink, white, and yellow roses; pink, red, and yellow canna flowers, and the flower-head of a red bergamot (Monarda didyma).

As a result of the increased collections of beetles at Niagara Falls during this second summer, about 14½ additional acres of Queen Victoria Park were sprayed in October 1941, and approximately ¾ of an acre of residential property in the city of Niagara Falls was given the standard treatment in April 1942.

Commencing in June 1942, an aggregate total of over 1,600 traps was placed in the field at the eastern end of the Niagara peninsula. At least 800 of these were set out near Niagara Falls, the trap lines, or groups, extending from the village of Chippawa on the south, chiefly through Niagara Parks Commission property, and private estate grounds, to Queenston Heights on the north. Also inland from the River within the city limits as far west as a line bordered approximately by Fourth, Lewis, and Stanley Avenues. A further 800 or more traps were distributed as follows:—200 at Fort Erie; 100 at Ridgeway; 120 in the Port Colborne-Humberston-Dane City area; 200 at Welland; 100 at Thorold; 20 at Port Robinson; 50 at St. Catharines, and 15 at Port Weller.

The first beetle for the year 1942 was found on July 11, in a trap placed on treated ground in Queen Victoria Park, and the last for the season were taken by the hand collection method, on September 26, from wild grape, and a nettle plant, at a point situated on previously untreated ground within the military barrier zone near the Horseshoe Falls. Between those dates, a total of 372 Japanese beetles, 168 males and 204 females, were trapped, or collected by the hand picking method, in the Niagara Frontier area; 15 at Fort Erie; 4 at Welland; 1 at Queenston, and the rest at Niagara Falls.

The situation at Fort Erie, where an unusually large percentage of the 15 beetles taken were females, 11 to only 4 males, and with the exception of two trapped in Mathers Park, Fort Erie South, the apparent tendency to concentrate within the area of two or three residential blocks at Fort Erie North (formerly Bridgeburg), would indicate an infiltration which although still small would nevertheless carry great potentialities for the establishment of a serious infestation and breeding ground. The two beetles, both females, trapped in Mathers Park, Fort Erie South, one near the Peace bridge and the other at the extreme southern end of the Park, would seem to be part of a separate flight, or artificially transported infiltration, for although they were both taken on August 18, well within the period of beetle capture for Fort Erie in general which extended from August 12 to September 14, nevertheless the distance separating the two areas of occurrence, at least two miles, would make it appear unlikely that there was any connection between the captures south of the Peace Bridge, across the River from central Buffalo, and those taken north and west of the International bridge, and more or less opposite the Black Rock railway yards, in north Buffalo.

The beetles taken at Welland, and at Queenston, were all males, and as those at Welland were captured at rather widely scattered points within the city, and the solitary one at Queenston Village taken under very unusual circumstances in an amateur entomologist's light trap, and in the face of negative results from the large battery of regulation scent traps situated among the extensive lawn and flower bed areas on the adjacent heights, it would seem that the captures at those two centres could be very well attributed to far

straying individuals, rather than to real infiltrations, or the beginnings of definite infestations.

Of the 352 Japanese beetles taken at Niagara Falls during the season, the previously treated ground in Queen Victoria Park only yielded 15 specimens; 11 males and 4 females. Of these 10 were trapped, and the other 5 hand collected from rose flowers, red zinnia, red canna, and giant knotweed.

Somewhat scattered, and not previously treated city properties produced 12 beetles by trapping, of which 9 were males and 3 were females; while another male was taken near the Canadian National railway bridge, and a female was found on September 4 in a trap situated among park boulevard rose beds near the Whirlpool, the most northerly point at which the beetle has been taken as yet in the immediate Niagara Falls area.

In, or around Queen Victoria Park, at points outside the treated area, a male was taken by hand on a red canna from a massed crescent bed of that brilliant flower, in the Oakes Garden Theatre on August 12, and another male was found on September 25, in a trap situated at the very bottom of the River Gorge, near the Maid-of-the-Mist landing.

With the exception of 5 beetles trapped around the Park Refectory between August 24 and September 15, and 4 specimens, 1 male and 3 females, taken within the period July 22 to September 24 on the Hydro Electric Power Commission lawns near Falls View, both localities quite near enough to be associated, practically all other captures at Niagara Falls not previously mentioned, took place at the foot of a high wooded slope just south of the searchlight tower, and directly facing Goat Island across the narrowed River Gorge immediately before it widens out to form the vast crescent of the Horseshoe Falls.

On this natural embankment, where sloping close cropped lawns rising from the River boulevard end abruptly at the base of a steep heavily wooded slope, there were trapped, or hand collected, between September 3 and 26, a total of 312 specimens of the Japanese beetle, of which 134 proved to be males, and 178 were found to be females.

At this point of greatest capture, traps which were finally concentrated at 25 feet intervals along the edge of the lawn, where it joins the wooded slope, took 123 beetles; while scouting, or the hand collecting method, resulted in 189 captures.

The entire collection of 189 hand taken beetles, and practically all of the 123 specimens trapped in this enclosed military area were, with the exception of two or three far flying males taken in traps some distance to the south, found concentrated in a comparatively small section of territory. The environment is a curious mixture of old and new, where well trimmed lawns and small ornamental evergreens suddenly give place to what is apparently an ancient natural embankment for the River, now densely covered with an indigenous growth of trees, shrubs, and vines. Ecological conditions would appear to indicate a typical transition life zone woodland, with a vegetative association of linden, ash, beech, elm, maple, sumac, dogwood, and wild grape, all over-topped by several gigantic tulip trees, and fringed in damp spots at the bottom of the slope, by a few low growing willows.

The general conditions of capture and occurrence at this point of beetle concentration would appear to clearly indicate a recent infiltration in force,

unassociated in anyway with tourist traffic, or other artificial means of dissemination, for the area is well within a closed military zone, and not accessible to the general public, or exposed to commercial traffic. Further, although traps were not placed inside the military area until about a week or ten days before the first beetles were taken, heavy concentration of traps, placed early in the season around the Park Refectory, outside the wire and immediately to the north of the search-light tower, did not take any beetles until August 24, and then followed with the capture of 4 specimens between September 9 and 15. In addition, the considerable number of traps, also in operation throughout the season, on the extensive Hydro Electric Power Commission lawns which stretch westward from the top of the high embankment in question to Buchanan Street in the City, took only one beetle on July 22, and that at a point further from the River; the other three from these lawns not being captured until the period August 28 to September 24.

It is possible, and would appear to be even highly probable, that toward the last of August, or the first of September, a flight of considerable magnitude was caught in an upward surge of air, wafted across the River gorge, and deposited on this sheltered embankment, where finding conditions favourable, it remained to feed and mate, with no apparent inclination to wander very far, throughout the greater part of the month of September.

From September 3, the date on which the first beetles were taken, until September 21, scouting and trap attendance took place in the area almost daily, a circumstance which made it possible to obtain a fairly clear picture, interrupted by some upward fluctuations toward the middle of the month, of a gradual decline of population from the high point of 67 captures on the first day of discovery to only 3 specimens on the last day of regular inspection.

The scouting operations in this area carried out regularly at first, as indicated above, and then intermittantly until the beginning of October, resulted within the period September 3 to 26th, in the hand collection of 87 Japanese beetles from willow; 55 from wild grape vines; 38 from Virginia creeper; 1 from an elm leaf; 3 from giant knotweed *Polygonum* sp.; 1 from a three-seeded mercury plant *Acalypha virginica*; 1 from a species of neetle; 2 from low herbage and grass, and 1 plucked from an inspector's coat.

The whole of the area around the Horseshoe Falls, including the woodland and lawn at the point of heaviest beetle concentration, is subject to periodic drenchings by spray from the nearby cataracts, and from December to late in March, or early in April, the vegetation is frequently covered with a heavy coating of ice, sometimes solid, and at other times granulated in character. These frequent drenchings tend to influence the temperature in contrast to that of the surrounding territory to quite a marked extent throughout the year, creating a cool damp atmosphere in late spring and early summer, and a warm and more humid condition from the later part of summer until quite late in the autumn. That insect life is active at this point for a considerable time after it has disappeared from more exposed localities nearby, is not only supported by our own direct observations, but is amply evidenced by late straggling migrants of the swallow family which are apt to be found on cold windy days in late September or early October coursing up and down over the comparatively sheltered lawns, and apparently feeding on the flying insects which cannot be found elsewhere in the vicinity during such weather.

Necessary control measures, involving the thorough treatment with arsenate of lead of lawns and probable breeding grounds in this area of greatest beetle

concentration, will make it next to impossible to draw accurate conclusions regarding the effect of the very localized weather conditions and temperatures on the Japanese beetle population at this point, but nevertheless it will be a most interesting and important area to watch, not only in respect to the possibility of fresh infiltrations another year, but also on account of the frequent spray drenching of the treated grounds, and the danger that such conditions, and the resulting masses of melting ice, may have a deleterious, or curtailing, effect upon the value of treatment in general.

For excellent scouting work, and valuable assistance rendered in connection with the large collections of Japanese beetle taken near the Horseshoe Falls, the writer is indebted to Messrs. Gregory, Featherston, and Hicks of the Niagara Plant Protection staff; while for several examples hand-picked from flowers and weeds in the general vicinity of the Rose Garden, Queen Victoria Park, thanks are due to the park gardeners, especially to Messrs. J. Slinn and A. Homewood. Grateful acknowledgement is also made to Mr. G. H. R. Laidman and young son of Queenston Village for many insect reports indicating unusually keen observations and watchfulness in connection with this pest, and into whose insect light trap the only Japanese beetle taken in that area found its way between 8:30 P.M. and 7:30 A.M. D.S.T. on the night of July 28-29, 1942.

THE EUROPEAN CORN BORER SITUATION IN ONTARIO IN 1942

By R. W. Thompson

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A reduction in the percentage of stalk infestation by European corn borer occurred throughout most of Ontario during 1942. In those counties of the province comprising the area where clean-up regulations are in effect, as can be seen from the accompanying table, reductions in the average percentage of infested stalks occurred in all counties except Kent, Elgin and Oxford. In these three counties there was actually a reduction in the corn borer population since, as was the case throughout the clean-up territory generally, the number of borers per stalk was decreased, in most cases a single larva occurring in an infested stalk. In 1941 borers were found in groups in the infested stalks, three to four often being present in one stalk, but with adjacent stalks free from infestation. In 1942 single borers only were found in most of the infested stalks examined, indicating a comparatively smoother distribution.

Throughout the remainder of the province where clean-up regulations are not in effect the borer population was reduced to some extent, although in parts of Eastern Ontario there was an increase in a few localities. Serious damage did not result in those areas where increased borer populations occurred.

Commercial damage by borer was reduced in comparison with 1941, as might be expected from the reduced populations reported. Field corn was not injured to any significant extent and only very early sweet table corn showed commercial loss through larval feeding. Factory sweet corn showed a much lighter general infestation and therefore little loss was sustained even in the earlier packs of this crop.

Weather conditions in 1942 were less favourable for the borer than in 1941, despite the fact that there was more moisture. The night temperatures during the period of moth flight were lower than in 1941, with the result that apparently

Average Percentage of Stalks Infested by Corn Borer

COUNTY	*1926*	*1927*	*1928*	*1929*	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*	*1936*	*1937*	*1938*	*1939*	*1940*	*1941*	*1942*
Brant	10	16	15	10	....	7	15	15	....	3	4	19	....	25	63	25	25
Durham	....	6	....	21	12	11	....	....	9	17	15	18	27	....	49	....	19
Elgin	48	37	24	21	9	17	23	17	7	18	16	25	50	40	70	29	33
Essex	83	65	42	36	17	28	28	30	9	20	32	47	34	29	68	34	31
Haldimand	4	30	12	8	....	....	....	....	6	4	6	15	....	....	62	....	24
Halton	....	....	....	9	12	13	12	17	11	8	15	7	20	....	57	....	28
Hastings	....	....	....	10	27	13	....	....	....	....	25	13	....	....	....	....	....
Huron	11	17	12	16	....	....	....	28	....	14	....	16	....	....	46	19	19
Kent	70	49	35	21	22	27	29	35	6	24	20	44	42	34	73	34	35
Lambton	34	57	21	14	7	....	35	23	8	21	20	31	41	38	81	40	36
Lennox	.5	2	12	22	33	27	19	18	....	....	46	18	....	....	....	....	....
Lincoln	5	43	30	11	9	11	13	20	5	4	12	6	....	5	39	33	24
Middlesex	29	36	18	10	9	15	22	20	5	6	14	22	34	33	64	29	25
Norfolk	16	10	20	6	5	5	11	9	3	9	4	30	26	27	70	26	18
Northumberland	....	....	....	18	16	8	....	....	5	....	15	13	....	....	41	....	15
Ontario	....	....	....	9	4	5	....	....	15	17	23	19	21	....	50	....	....
Oxford	31	14	15	18	....	13	16	17	6	17	19	34	29	28	70	22	24
Peel	....	....	10	19	17	22	29	39	11	12	12	11	....	....	63	30	32
Pelee Island	....	....	15	24	5	6	7	12	4	9	13	22	13	17	26	....	....
Perth	....	8	9	16	....	....	....	6	....	12	....	20	....	45	64	25	17
Prince Edward	....	....	18	21	28	17	....	....	....	44	27	22	....	....	....	....	....
Waterloo	....	....	8	5	....	....	13	11	....	7	....	12	....	25	66	22	20
Welland	24	41	26	5	14	10	....	7	2	4	4	16	12	....	35	31	19
Wellington	....	....	....	8	5	....	9	....	....	7	10	3	....	....	65	26	17
Wentworth	....	22	25	9	13	8	17	19	8	6	7	12	17	21	39	28	24
York	....	....	....	....	....	5	22	....	....	16	8	28	....	....	68	26	19

a significantly smaller number of eggs was laid and consequently a smaller population of borers was established.

From the standpoint of corn borer clean-up, compliance with the regulations concerning corn refuse disposal in 1942 was about equal to that of 1941. The acute shortage of help on Ontario farms and the unfavourable weather of the spring made clean-up operations difficult, more particularly where hand-picking and burning were involved, but the majority of corn growers made a reasonably thorough job of disposing of their corn remnants of all kinds.

Growers had intended to increase their corn acreage to a considerable extent in the husking corn counties but the extremely wet weather of the spring of 1942 made planting difficult and consequently the acreage remained approximately the same as in 1941. There was, however, a considerable increase in the acreage of hybrid corn in Ontario in 1942 and this fact also explains to some extent the decrease in the amount of commercial damage to both husking and ensilage corn crops. The hybrid strains of corn are by no means limited to the husking corn areas of the province and during 1942 were grown to a considerable extent throughout the ensilage counties. As has been noted in previous reports of this Society, the sturdiness of stalk, which characterizes a good many of these hybrid strains, makes them better able to withstand windstorm damage than the open pollenated varieties. Thus, even in fields where significant borer populations occur, especially in silage crops, hybrid strains make harvesting a simpler operation and the resultant stubble is left in a better condition for clean-up with less labour either by fall or spring ploughing.

IMPORTANT DEVELOPMENTS IN THE CORN BORER PARASITE SITUATION*

By Geo. Wishart

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Since the inception of the work with the parasites of the European corn borer, *Pyrausta nubilalis* Hubn. in 1923, a total of 4,709,714 adults of 17 distinct species and two additional races of parasites has been liberated in areas infested by this insect in Ontario, Quebec, New Brunswick and Nova Scotia. Over four million of these were of two species, *Microbracon brevicornis* Wesm., and *Exeristes roborator* Fabr., species of which only a few recoveries of very doubtful value have been made. The remainder, about three quarters of a million parasites, were of species some of which have shown considerable promise. It was shown (1) that extensive liberations gave gratifying initial recoveries of such species as *Inareolata punctoria* Roman, *Chelonus annulipes* Wesm., *Macrocentrus gifuensis* Ashm., and *Lydella stabulans* R.D. A few other species gave recoveries of a less promising nature. In spite of the fact that in some cases continued supporting releases were made, no evidence appeared until 1940 to indicate a natural build up of any species. In every case where good initial establishment was secured, it was followed by a rapidly diminishing population.

In 1937 extensive recovery collections made in Essex County along the shore of the Detroit River yielded a few dipterous puparia from which the flies had

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Table I

Collections of Corn Borer Larvae Made in South Western Ontario for Recovery of Introduced Parasites

August 20-24, 1940

Location	No: Hosts Examined	*Lydella stabulans* R.D. Puparia in Field: Emerged	*Lydella stabulans* R.D. Puparia in Field: Unemerged	*Lydella stabulans* R.D. Puparia formed in Laboratory	% Parasitism by *Lydella*	*Eulophus viridulus* Thoms.	Other Parasites
Tecumseh	327		1		.3		
Windsor (South)	80		4	5	11.2		
LaSalle	158	13	15	10	24.0	1	2 *Lixophaga variabilis* Coq.
LaSalle, 2½ miles from River	169	1	6	3	5.9		
LaSalle, 1 " South	13		3		23.1		
Amherstburg, Windsor (½ Way)	168	24	20	15	35.1		1 *Eupteromalus* sp.
Amherstburg (2 miles North)	192	16	35	11	32.3		2 " "
Amherstburg (1 " ")	62	1	6	6	20.9		1 *Lixophaga variabilis* Coq.
Amherstburg (1 " East)	85	1	7	7	17.7		1 *Eupteromalus* sp.
Oxley (2 miles West)	130		1		.7		
Amherstburg, Leamington (½ Way)	199		2		1.0		
Pt. Pelee	85	1	1	1	3.5		
Pt. Pelee - Leamington	46	2			4.3		
Leamington (½ mile South)	149				.0	1	2 *Lixophaga variabilis* Coq.

emerged. These were identified as of *Lydella* sp. and although positive identification could not be made without the flies, it was felt that they were probably *L. stabulans* R.D. an imported parasite.

In 1940 recovery collections were arranged to secure any parasites that might be present before emergence of adults took place. Collections were made between August 20 and 24th in the area along the shores of Lake St. Clair, the Detroit River, and Lake Erie, from Tecumseh to Leamington. The data secured from these collections are tabulated below:

It will be noted that *Lydella* was taken in all but one collection and that the highest parasitism occurred in the area along the shore between Amherstburg and Windsor. This is in keeping with the recoveries of this parasite in Ohio and Michigan, where it has been found most abundant near marshes. It is further borne out by two collections made at LaSalle where parasitism was 24 per cent. at the river and only 5.9 per cent. at a distance of two and a half miles directly back from it. Notable also was the recovery of *Eulophus viridulus* Thoms. at two widely separated points, Windsor and Leamington. This constituted the first recovery of this species made in Canada other than those of an initial nature.

No liberations of *Lydella* have been made in this area since 1932 and none of *Eulophus* since 1931. They have, therefore, been present in these areas in such small numbers that recovery studies have failed to reveal their presence or they have come in from other areas where they had become established.

Data secured from recovery collections made in Western Ontario in 1941 and 1942, in most cases, show a decrease in percentage of parasitism by *Lydella*, but they also provide some new and interesting data on distribution. *Eulophus* showed a very remarkable extension in distribution and at some points a considerable increase in the degree of attack. Table II shows the percentages of parasite attack by *Lydella* and *Eulophus* for the two years, 1941 and 1942.

TABLE II

COLLECTION OF CORN BORER PARASITES MADE IN SOUTH-WESTERN ONTARIO FOR RECOVERY OF INTRODUCED PARASITES

July, 1941 and September, 1942

Location	% Par. *Lydella* 1941	% Par. *Lydella* 1942	% Par. *Eulophus* 1941	% Par. *Eulophus* 1942
Dresden	....	0	....	8.3
Chatham	.9	0.0	5.3	2.2
Tecumseh	0.0	0	0	0
LaSalle	9.3	10.4	0	0
Amherstburg	11.2	1.0	0	0
Oxley	1.7	0.0	0	3.3
Leamington-Pt. Pelee	1.4	1.1	3.6	.7
Erieau	.7	....	1.4	....
Cedar Springs	0	2.1	.6	0
Port Stanley	0	0	.2	0
Port Burwell	3.7	....	.9	....
St. Williams	4.4	....	0	....

.... Indicates no collection was made.

The decrease in parasitism by *Lydella* was associated with a considerable reduction in corn borer population and may have been related to it. Also, due to decreased acreage it was impossible to make as extensive collections in sweet

corn as in 1940, and up to the present parasitism has been highest in early sweet corn. As was indicated earlier, the presence of *Lydella* in numbers appears to be associated with a particular type of marsh which is common along the Detroit River and Lake Erie. The spread of this parasite may be limited, therefore, to areas where this type of environment exists. Its presence at points as far away from the centre of greatest population as St. Williams and Port Burwell is very gratifying and indicates that further spread may be anticipated.

The recovery of *Eulophus* at Port Stanley and Port Burwell shows that it has very great powers of dispersal. Considering this point, it would appear unlikely that high concentrations of this parasite would be found for some time. In view of this condition the record of 8.3 per cent. parasitism by this species at Dresden is particularly gratifying.

Observations also indicate that changes are taking place in the corn borer population itself. There is a considerable amount of evidence that a second generation of the borer is developing in Western Ontario and that the true multiple-generation strain from New England is well established in Southern Quebec. The available evidence from Western Ontario consists of pupation being found in the field as early as July 25. These data are presented in Table III.

TABLE III

DATA ON PUPATION OF BORERS OBTAINED FROM COLLECTIONS MADE IN SOUTH-WESTERN ONTARIO FOR RECOVERY OF INTRODUCED PARASITES

Year	*Date of Collection*	*Average Pupation*	*Maximum Pupation*	*Point of Max. Pupation*
1940	Aug. 21	3.09%	13.0%	Oxley
1941	July 25	2.25	15.1	Oxley
1942	Sep. 3	9.2	21.1	Leamington

Extensive summer collections have not been made in Southern Quebec but data from material wintered outdoors and reared in the laboratory at 74 degrees F. show two peaks of pupal formation, one occurring at the normal time for one generation material and one at twelve days. The early pupating individuals undoubtedly belong to the true multiple-generation strain of borer. The percentage of these at St. Jean in 1942 was approximately 2.5 per cent. and at Isle Bizard .5 per cent. Pupation in the St. Jean collections is indicated in Figure I.

Approximately 80 per cent. of the pupae of overwintering larvae of the multiple-generation strain were parasitized by the native parasite, *Labrorychus prismaticus* Nort. This parasite is also reported to occur on *Tortrix cerasivorana* Fitch. and its presence on corn borer may be related to the presence of *T. cerasivorana* in this area. If this high parasitism continues, the development of a large population of this strain of the borer will undoubtedly be retarded.

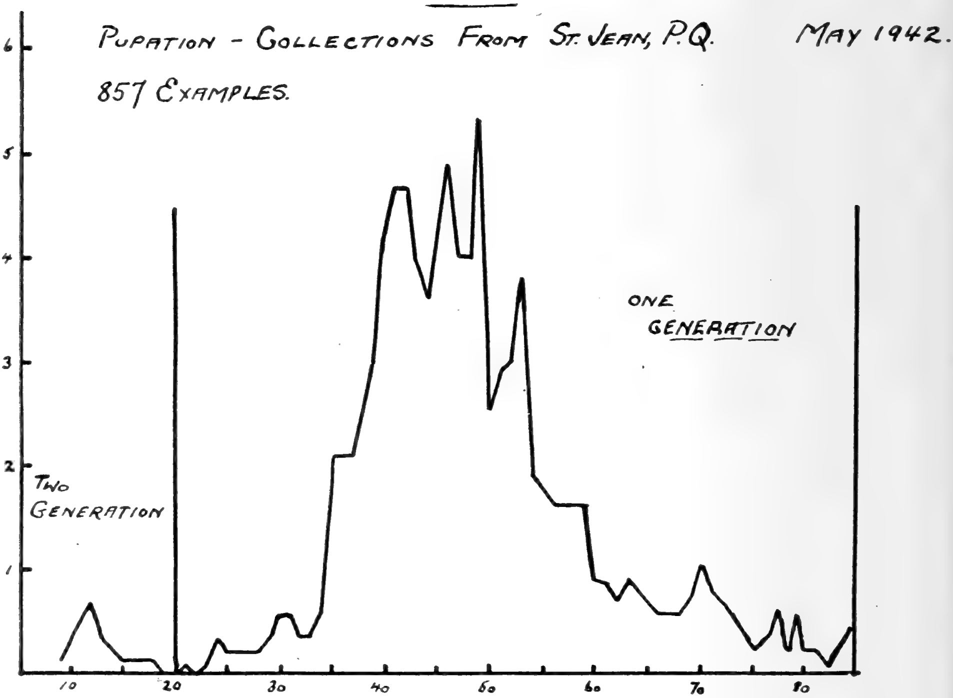
The establishment of the parasites of the corn borer has met with more success in New England where the strictly multiple-generation strain occurs than in our one-generation areas. This is particularly so with the parasites *Macrocentrus gifuensis* Ashm., and *Inareolata punctoria* Roman. There is evidence to show that this is the case because these parasites emerge too early to be present when the larvae of the single generation strain appear in the field.

The appearance of the multiple-generation strain in Quebec and the development of a second generation in Western Ontario may be matters for some concern but their presence may on the other hand make possible the establishment of parasites which have not been established up to this time. The benefit thus derived may more than counterbalance any ill effects.

REFERENCE

(1) WISHART, GEO., AND THOMAS, I. E.—Recent Developments in the Corn Borer Parasite Situation in Eastern Canada. Ann. Rep. Ent. Soc. Ont., 63, 1932.

FIGURE I



THE VALUE OF MOLASSES-FREE BAITS IN THE CONTROL OF CUTWORMS IN TOBACCO FIELDS*

By

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Cutworms are common pests in tobacco fields and their control must be practiced annually in most tobacco-growing areas of Ontario. This is particularly

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so in Norfolk County where most fields are infested. For many years, the majority of growers has controlled cutworms by the use of a standard poisoned bait composed of bran, 25 lb.; paris green, 1 lb.; molasses, 1 qt., and water, $2\frac{1}{2}$ to 3 gal. Some growers have also used a commercial stock food, containing some molasses, to which they added paris green and water. In the spring of 1942, war-time regulations restricted the distribution of molasses, causing a lack of this material for use in baits. With the advent of this measure, the Dominion Department of Agriculture and the Ontario Department of Agriculture issued, jointly, recommendations for cutworm control by the use of the standard bait without molasses. Some concern arose over this action, the contention being that molasses was necessary to attract cutworms. Accordingly, the problem was investigated by making preliminary field tests with various poisoned bait mixtures.

Methods: The officers of the Dominion Entomological Laboratory, Chatham, and the Department of Entomology, Ontario Agricultural College, Guelph, co-operated in carrying out two experiments. The primary object in these experiments was to determine whether molasses was absolutely necessary as a bait ingredient. Also, tests were made on the relative control values of baits composed of various carriers, poisons, and wetting agents. The experiments consisted of applying baits to infested field plots, then planting tobacco and observing the control effected. The control values of the various baits tested were based on the amount of plant injury or plant establishment occurring in the treated plots.

Details of experimental work: One experiment, under the direction of the Chatham laboratory, was carried out in a three-acre field on the property of the Dominion Experimental Sub-station, Delhi. The second experiment, under the direction of the Ontario Agricultural College, was carried out in a ten-acre field on a commercial plantation at Teeterville. Both fields were typical tobacco fields infested with cutworms, and consisted of smooth lake-sediment soil of the Fox and Berrien type, characteristic of the tobacco-growing areas of Norfolk County. These fields were examined for cutworms to determine the infesting species. In the Delhi field, five different species were present including *Euxoa messoria* Harr., *E. detersa* var. *personata* Morr., *E. tessellata* Harr., *Feltia ducens* Wlk. and *Crymodes devastator* Brace. The first two species were the most common throughout the field and made up the greater portion of the population. In the Teeterville field, *E. messoria* and *E. detersa* var. *personata* were the infesting species, *E. messoria* being the most prevalent.

The fields were prepared, baited, and tobacco planted, in so far as possible, according to the average field practices of growers in the district. Baiting and planting were to be done at the time when the majority of growers carries on these operations. In an average season, in Norfolk County, most fields are baited during the last week of May and tobacco planted during the first week of June. The weather during this period is usually quite warm and dry, and cutworms are quite active. However, in the spring of 1942, the season was unusually cool

and wet and cutworm activity was sluggish. Baiting the experimental plots was delayed until the first week of June, but even then a really favourable evening did not occur. Therefore, the tests were not made under the normal conditions of weather which usually prevail in Norfolk County.

The experiment at Delhi was planned and carried out to determine the relative control values of various poisoned bait mixtures as compared with the standard bait and with one another. In particular, this experiment was carried out to determine (1) whether molasses is necessary in a cutworm bait, (2) whether some carrier other than bran may be used effectively, (3) which poisons other than paris green may be used to advantage, and (4) whether a lubricating oil may be used effectively in place of molasses and water. The experiment at Teeterville consisted of testing the relative control values of certain carriers and wetting agents when used in baits on a commercial scale.

Materials tested: The materials tested as carriers included wheat bran, wheat distillers' dried grains, sugar-beet pulp and a commercial stock food which consists largely of sugar-beet pulp. Previous to 1942, it contained some molasses, but in 1942 the material available contained oil in place of the molasses. Only the commercial stock food, with oil, was used in the Delhi experiment, whereas in the Teeterville experiment, both the molasses and oil mixtures were used, and water was added to the oil mixture since some growers were using the new material in this way. The poisons used were paris green, white arsenic, sodium arsenite and sodium fluosilicate. A light lubricating oil, SAE 20, with low sulphur content was used. The preparation of the baits and the proportion of ingredients used conformed, in so far as practicable, to those of the standard bait. The amount of water used in any mixture depended upon the absorptive capacity of the carrier. The bran took up somewhat less water than the minimum required in the standard bait mixture, while the other three carriers absorbed, in varying amounts, more than the minimum. The poisons, white arsenic and sodium arsenite, were used in amounts proportionate to their AS^2O^3 content as compared with that of paris green. The various baits tested and their composition are shown in Table I.

Field technique: In the Delhi experiment, twenty-two different bait treatments, including the standard bait and checks, were applied in four replications to randomized plots 40 feet square. Baiting was done on June 2, using the various mixtures at the rate of 20 pounds per acre (dry weight of carrier). Each plot was entirely baited and observations on the effects of treatments were made within the central 20 square-foot area of each plot. This arrangement allowed a buffer area of 20 feet between plots. Tobacco was planted on June 6. Plant injury counts were made on June 7, 8, 9 and 10, and plant establishment counts on June 24.

In the Teeterville experiment, five of the same mixtures as used at Delhi were tested. These included treatments 2, 3, 7, 11 and 14, as shown in Table I, and in addition, treatment 23, which consisted of the 1941 commercial preparation with molasses. Six plots, each measuring approximately 1.7 acres, were used. A different bait mixture was applied to each plot at the rate of 25 pounds per acre (dry weight of carrier). Baiting was done on June 4 and tobacco planted June 8. The effects of treatments were observed by making injury counts from 200 plants in each of 8 rows in each plot. Separate counts were made on June 10, 11 and 15.

TABLE I. BAIT MIXTURES TESTED IN CONTROL OF CUTWORMS IN TOBACCO FIELDS, NORFOLK COUNTY, ONTARIO, JUNE 1942

Bait treatment No.	*Bait composition*
1	Bran, 25 lb.; paris green (56% AS^2O^3) 1 lb.; molasses, 1 qt.; water, 2 gal.
2	Bran, 25 lb.; paris green, 1 lb.; water, 2 gal.
3	Distillers' grains, 25 lb.; paris green, 1 lb.; water, 3½ gal.
4	Bran, 25 lb.; arsenic (98% AS^2O^3), 9 oz.; water, 2 gal.
5	Bran, 25 lb.; sodium arsenite (60% AS^2O^3), 15 oz.; molasses, 1 qt.; water, 2 gal.
6	Bran, 25 lb.; sodium arsenite, 15 oz.; water, 2 gal.
7	Distillers' grains, 25 lb.; paris green, 1 lb.; oil, ½ gal.
8	Bran, 25 lb.; sodium fluosilicate, 1 lb.; water, 2 gal.
9	Bran, 25 lb.; water, 2 gal. (Check)
10	Distillers' grains, 25 lb.; oil, ½ gal. (Check)
11	Bran, 25 lb.; paris green, 1 lb.; oil ½ gal.
12	Beet pulp, 25 lb.; paris green, 1 lb.; water, 3 gal.
13	Bran, 25 lb.; arsenic, 9 oz.; oil, ½ gal.
14	Commercial preparation (with oil), 25 lb.; paris green, 1 lb.
15	Bran, 25 lb.; sodium arsenite, 15 oz.; oil, ½ gal.
16	Commercial preparation (with oil), 25 lb. (Check)
17	Bran, 25 lb.; sodium fluosilicate, 1 lb.; oil, ½ gal.
18	Bran, 25 lb.; oil, ½ gal. (Check)
19	Distillers' grains, 25 lb.; paris green, 1 lb.; molasses, 1 qt.; water, 3½ gal.
20	Distillers' grains, 25 lb.; water 3½ gal. (Check)
21	Beet pulp, 25 lb.; paris green, 1 lb.; molasses, 1 qt.; water, 3 gal.
22	Beet pulp, 25 lb.; water, 3 gal. (Check)
23	Commercial preparation (with molasses and no oil), 25 lb.; paris green, 1 lb.; water, 2 1-3 gal. (Teeterville experiment only)

Results: Although plant injury counts were made at different periods of from two to seven days after planting tobacco, only the results from the later counts

are presented, since these values afford a better measure of the control effected by the various baits than the injury occurring over a shorter period. The results obtained from plant injury and plant establishment counts in the Delhi experiment are shown in Table II. Results of plant injury counts in the Teeterville experiment are shown in Table III. In appraising these results, the control values of the various bait mixtures depend upon the degree of plant injury or plant establishment occurring in the plots. The average tobacco grower considers that with one proper application of bait the loss of 5 per cent. of plants from injury, or the establishment of 95 per cent. of plants, is commercially successful. On this practical basis, the control values of the baits may be evaluated.

In the Delhi experiment, 12 different treatments, including the standard bait, reduced plant injury to 5 per cent. or less, and 5 of these treatments were more effective than the standard bait. Three other treatments were marginal in their effect on reduction of injury to the commercial level. The mixture containing the commercial preparation with oil, was no more effective than a check. Eight different baits, exclusive of the standard bait effected establishment of 95 per cent. or more and for practical purposes all were equally effective. The standard bait produced 91 per cent. establishment. Three baits were more effective than the standard bait, but did not produce commercial establishment. Three other baits effected establishment ranging from only 84 to 89 per cent. Establishment from the commercial preparation with oil mixture was no better than a check.

Molasses did not add to the effectiveness of the bran and paris green mixture either in the reduction of injury or establishment of plants. The addition of molasses to the mixtures containing beet pulp and distillers' grains appeared to add somewhat to their effectiveness, especially in the case of the distillers' grain mixture. Of the various carriers tested, bran was the most effective. Beet pulp was more effective than distillers' grains, while the commercial preparation was decidedly ineffective. In the bran mixtures with water or water and molasses, the three poisons, arsenic, sodium arsenite and sodium fluosilicate, were equally as effective as paris green. Oil, as a wetting agent, was equally as effective as water when used with the poisons sodium arsenite and sodium fluosilicate, but was of doubtful value when used with paris green. In the mixture containing arsenic, oil was decidedly ineffective.

In the Teeterville experiment, similar results were obtained. The bran and paris green mixtures, without molasses, reduced injury to 5 per cent. or less, the oil mixture being almost as effective as the water mixture. The baits containing distillers' grains were ineffective in reducing injury or establishing plants on the commercial level. However, the water mixture was appreciably more effective than the oil mixture. The commercial preparation with oil mixture was more effective in this experiment than in the Delhi experiment, but did not reduce plant injury to the commercial level. The addition of water to the mixture used at Teeterville may have produced this effect. With molasses, used only in the Teeterville experiment, it was not effective in reducing plant injury to 5 per cent., but was more effective than the distillers' grain mixtures.

TABLE II. PLANT INJURY AND PLANT ESTABLISHMENT OBTAINED FROM VARIOUS BAIT MIXTURES TESTED IN EXPERIMENTAL PLOTS, DELHI, ONTARIO, JUNE 1942

Treatment No.	*Bait Mixture*	*% plant injury 8 days after baiting, 4 days after planting*	*% plant establishment, 18 days after planting*
4	Bran, arsenic, water	0.0	98
2	Bran, paris green, water	.4	98
8	Bran, sodium fluosilicate, water	.8	99
5	Bran, sodium arsenite, molasses, water	.8	96
6	Bran, sodium arsenite, water	.8	99
1	Bran, paris green, molasses, water	1.2	91
17	Bran, sodium fluosilicate, oil	1.2	97
15	Bran, sodium arsenite, oil	1.7	98
11	Bran, paris green, oil	2.0	94
21	Beet pulp, paris green, molasses, water	3.7	95
19	Distillers' grains, paris green, molasses, water	4.9	94
12	Beet pulp, paris green, water	4.9	93
3	Distillers' grains, paris green, water	5.4	89
7	Distillers' grains, paris green, oil	6.4	84
13	Bran, arsenic, oil	7.0	88
16	Commercial preparation with oil (Check)	8.6	88
9	Bran, water (Check)	9.9	84
18	Bran, oil (Check)	12.4	73
22	Beet pulp, water (Check)	13.3	73
14	Commercial preparation with oil, paris green	15.2	70
10	Distillers' grains, oil (Check)	16.9	76
20	Distillers' grains, water (Check)	22.9	62

TABLE III. PLANT INJURY OBTAINED FROM VARIOUS BAIT MIXTURES TESTED IN EXPERIMENTAL PLOTS, TEETERVILLE, ONTARIO, JUNE 1942

Treatment No.	*Bait mixture*	*% plant injury 11 days after baiting, 7 days after planting*
2	Bran, paris green, water	3.7
11	Bran, paris green, oil	4.6
23	Commercial Preparation (with molasses), paris green, water	6.1
14	Commercial preparation (with oil), paris green, water	8.4
3	Distillers' grains, paris green, water	12.3
7	Distillers' grains, paris green, oil	17.8

Discussion of results: Since these two experiments were preliminary in nature, we cannot come to definite conclusions about the relative control values of the various mixtures tested. The results obtained are from one season's work and the season was one of unusual weather conditions. However, we can be sure of certain trends. Molasses does not appear to add to the effectiveness of a bran bait, but may be of value in mixtures containing beet pulp or distillers' grains. Bran appears to be the most effective carrier among those tested. The poisons, arsenic, sodium arsenite, and sodium fluosilicate appear to be as effective as paris green in bran and water mixtures. Oil, as a wetting agent, appears to be satisfactory in bran mixtures when used with sodium arsenite or sodium fluosilicate as poisons. When used with arsenic or paris green, the oil was of doubtful value, both in the bran mixtures and with distillers' grains. Further tests are required to determine definitely the most effective ingredients and combinations of them for a satisfactory cutworm bait.

Conclusions: In considering the results as a whole, it appears at the present time that the control of cutworms in tobacco fields may be confidently carried out by the use of a bran and water bait, without molasses. It is not advisable to suggest the use of other carriers than bran or other wetting agents than water until further investigations are made on the use of these. Any one of the poisons tested appears satisfactory. However, as growers have used paris green over a long period and are familiar with it, this poison is the one to use until additional tests are made with other poisons.

Acknowledgements

The original plans and arrangements for the experiments were largely due to the efforts of Dr. Geo. M. Stirrett, Entomologist in Charge, of the Dominion Entomological Laboratory, Chatham, and Professors A. W. Baker and R. W. Thompson of the Department of Entomology, Ontario Agricultural College, Guelph. Mr. F. A. Stinson, officer in charge of the Dominion Experimental Sub-station, Delhi, provided and prepared the infested field for the Delhi experiment and the Windham Plantations provided a commercial field at Teeterville. The actual field experimentation was carried out jointly by Messrs. D. A. Arnott, A. A. Wood and H. B. Wressell of the Chatham Laboratory, and Messrs. H. W. Goble and H. E. Scott of the Ontario Agricultural College.

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THE WHITE GRUB SITUATION IN ONTARIO DURING 1942 AND A FORECAST FOR 1943*

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White grub losses in Bruce County proved to be comparatively light for the season. Considerable damage, however, to field and nursery crops occurred around the southern and western sides of Lake Simcoe. In southwestern Ontario, the region of severe infestation which centres on the area bounded by London, Brantford and Guelph, the outbreak was of very serious proportions and losses were severe, involving potatoes, strawberries, corn, grain, garden crops and pasture. However the high quality of the farm practice over much of the area reduced the potential losses very materially. Permanent pastures in the St. George and Galt areas were widely and severely infested, hundreds of acres of pasture being destroyed. In Wellington, Brant, Oxford and Halton Counties, grain with the exception of fall wheat was seriously injured on the slopes of the typical rolling hills. Field and garden corn likewise suffered throughout this district. However, much of the serious loss was avoided by the local practice of planting corn on land previously in hoed crops rather than on land which had been in sod in 1941.

Farther east the infested area included in the Counties of Peterborough, Northumberland, Hastings, Lennox and Addington, and Frontenac sustained a widespread and very devastating outbreak which resulted in extremely severe losses to field crops.

The white grub outbreak conditions were general throughout the entire County of Hastings, the most severe losses occurring from the central to the northern part of the County. Conditions between Marmora and Bancroft may be described almost as a continuous infestation with practically all susceptible crops being damaged to some extent. Pastures over large districts were completely destroyed or had their stock carrying capacity reduced by 75 per cent. or over. Injury to potatoes was spectacular. At several points such as Eldorado and Coe Hill complete loss of crop was common and on many farms the yield was of no commercial value on account of grub injury. Oats and barley in this district sustained losses up to 90 per cent. of the yield. However, injury to fall wheat was limited to spots on sloping land. Damage to corn occurred commonly but was much less than was expected owing to the increased attention given to

*Contribution No. 2228, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

control recommendations resulting in the planting of much of the corn crop on land which had been in hoed crop in 1941 or by reducing the white grub population by the shallow ploughing-multiple disking treatment of sod land before planting the corn. In Hastings County and the surrounding area, heavy rains in the early summer stimulated hay and pasture to rapid vigorous growth before the white grubs began their severe feeding and materially reduced the extremely severe losses which otherwise would have occurred. In fields, however, where white grubs were present at the rate of 150,000 or more per acre, which included large areas in the County, pasture and meadow was largely destroyed by the latter part of the season and dead sod was largely replaced by various kinds of noxious weeds. Fortunately where the attack was not too severe, sufficient moisture was present in the soil in the late summer to allow of a considerable recovery of sod or turf in the autumn after the grub feeding had ceased.

In Peterborough, Lennox and Addington, Frontenac and Lanark, the infestation was much more scattered. However, many fields of severe white grub injury were observed but aggregate losses were much less than those in Hastings County. Nevertheless serious damage on many individual farms occurred to meadow, pasture, corn, and potato.

In eastern Ontario, although the losses were not as serious as farther westward, widespread damage occurred from Carleton and Grenville Counties eastward. Corn and potatoes suffered particularly but most susceptible crops were attacked and losses of up to 80 per cent. of the potato crop were found in some instances in the southern half of Grenville.

The significant white grub injury for 1942 was caused by the destructive second year grub stage (brood A) which will not be present or destructive again in the same area for a further three-year period. These (brood A) second year grubs will be destructive again in 1945 and 1948. In the meantime no significant, direct injury is to be expected and in the interval, control precautions, such as planting alfalfa to replace fibrous-rooted grasses such as timothy, may be taken to avoid future damage.

Elsewhere in Ontario, notably in Lambton County, the Niagara Peninsula and the Toronto-Uxbridge-Bowmanville triangle (brood C) grubs were in the third year stages in 1942 in which they feed little and direct injury to crop or plant roots was slight. Injury in future years from brood C will occur in 1944 and 1947.

The Situation in 1943,—

Throughout the greater proportion of Ontario the white grubs which were so destructive to crops in 1942 will be in the third year stages in 1943 and during the season will change into June beetles which will remain in the ground over winter, flying in 1944. As a consequence no direct loss from these insects is to be expected in the greater part of the Province. However, a large flight of June beetles is expected in May and June in a large region in central Lambton County in the Niagara Peninsula and in a zone included in the region between Toronto, Uxbridge and Bowmanville (brood C). Beetles are expected to be present in abundance and to cause serious defoliation to many forest, shade, and ornamental trees. It is expected that eggs will be deposited in the soil in large numbers, particularly in sod or turf and the young white grubs hatching from these eggs in July and August may cause some injury to pastures and meadows in late September. Except where these young white grubs are very numerous compara-

tively minor damage will be effected and unless the autumn is very dry, little permanent damage would be expected to result.

The farmers in Ontario, therefore, can look forward to 1943 as a year almost certainly free from direct or serious white grub injury, although defoliation from the mature stage or June beetles can be expected where beetles are abundant.

THE POTATO APHID SURVEY IN THE MARITIME PROVINCES AND EASTERN QUEBEC, 1942*

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Three summaries of progress in connection with this project have been published in the reports of the Entomological Society of Ontario. The last one gave the results of the work done in 1941. This report tells of the work in 1942 and notes the changes which were observed in field population. It also describes some extensions of the general work which were made desirable by facts learned in former years.

The sampling of the potato field population of aphids was done in the same general way as in other years—namely, the collection of four samples from different parts of a field in August together with a record of the nature of infestation, variety of potato, environment, slope of land, date since last heavy rain, etc. These samples were taken in part by the inspectors of the Plant Protection Division visiting farms where certified seed stock had been planted, and in part by officers of the Division of Entomology visiting ordinary farm fields. To all these officers our thanks are due for their cooperation.

The samples were received at Fredericton within twenty-four hours after collection. The samples were examined, the aphids identified, and a report on each sample mailed to the chief potato inspector and the entomologist in each province within eight hours after receipt. By this method the officers having most interest in the aphid population were kept informed from day to day of the changes taking place within their districts.

Samples were received from eighty-six farms in New Brunswick, sixty-nine in Prince Edward Island and seventy-six in Quebec. These were taken from representative parts of the potato growing regions in each province and in general range were from the eastern point of Prince Edward Island in west longitude 62° to Normandin, P.Q. in west longitude 73°; from the southern tip of the mainland in New Brunswick in north latitude 45.5° to the Peribonka River Valley, P.Q. in north latitude 49° No collections were made in Nova Scotia in 1942.

In the following tables are shown the 1942 records in comparison with those of 1941 and 1940 for the same territory.

*Contribution No. 2210, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Can.

TABLE No. 1—THE NUMBER OF FARM COLLECTIONS MADE IN 1940, 1941 AND 1942.

	1940	*1941*	*1942*
New Brunswick	182	123	86
Prince Edward Island	290	157	69
Quebec	99	68	76

TABLE No. 2—THE NUMBER OF FIELD SAMPLES RECEIVED IN 1940, 1941 AND 1942.

	1940	*1941*	*1942*
New Brunswick	751	376	287
Prince Edward Island	1419	610	276
Quebec	390	270	304

TABLE No. 3—THE NUMBER OF SAMPLES IN WHICH EACH SPECIES OF APHID WAS PRESENT AND THE PERCENTAGE OF THE WHOLE WHICH IT REPRESENTED.

	1940	*1941*	*1942*
New Brunswick			
Macrosiphum solanifolii	564	181	195
% of whole	75.09	48.13	67.94
Myzus persicae	313	265	203
% of whole	41.67	70.47	70.73
Aphis abbreviata	88	83	110
% of whole	11.71	22.07	38.33
Myzus pseudosolani	9	6	3
% of whole	1.19	1.59	1.05
Prince Edward Island			
Macrosiphum solanifolii	952	559	191
% of whole	67.08	91.63	69.20
Myzus persicae	374	282	109
% of whole	26.35	46.22	39.49
Aphis abbreviata	75	141	132
% of whole	5.28	23.11	47.82
Myzus pseudosolani	18	7	3
% of whole	1.26	1.14	1.08
Quebec			
Macrosiphum solanifolii	263	225	286
% of whole	67.43	83.33	94.08
Myzus persicae	95	153	141
% of whole	24.35	56.66	46.38
Aphis abbreviata	27	74	16
% of whole	6.92	27.4	5.26
Myzus pseudosolani	18	4	10
% of whole	4.61	1.48	3.29

TABLE No. 4—SHOWING THE GENERAL NATURE OF THE FIELD INFESTATION BY APHIDS AS NOTED ON RECORD SHEETS BY THE COLLECTORS OF SAMPLES.

New Brunswick			*Prince Edward Island*			*Quebec*		
Type of Infestation	*Total*	*per cent.*	*Type of Infestation*	*Total*	*per cent.*	*Type of Infestation*	*Total*	*per cent.*
			1940					
Very light	4	2.2	Very light	20	6.7	Very light	0	0.0
Light	75	41.2	Light	221	73.7	Light	57	59.4
Medium	70	38.5	Medium	40	13.3	Medium	29	30.2
Severe	33	18.1	Severe	18	6.0	Severe	10	10.4
			1941					
Very light	22	18.0	Very light	4	2.5	Very light	16	23.5
Light	86	70.5	Light	91	58.0	Light	15	22.1
Medium	9	7.4	Medium	44	28.0	Medium	17	25.0
Severe	5	4.1	Severe	18	11.5	Severe	20	29.4
			1942					
Very light	18	19.6	Very light	4	5.7	Very light	12	15.8
Light	25	27.2	Light	41	58.6	Light	16	21.0
Medium	25	27.2	Medium	19	27.1	Medium	34	44.7
Severe	24	26.1	Severe	6	8.6	Severe	14	18.5

The data presented in Table No. 3 shows that the common potato aphid, *Macrosiphum solanifolii* Ashmead, was present in 11% more of the samples from Quebec fields than in 1941. It was present in 19% more of the samples from New Brunswick fields but in contrast to these records it was present in 22% less of the samples from Prince Edward Island. Of the four species which are found upon the potato plant this is generally the most prevalent and also the most conspicuous since it feeds particularly upon the young and fast growing tips of the haulms and in July and early August upon the blossom stems. When a field collector reports a severe aphid infestation in a field the collections nearly always show this species present in all four samples.

In July and August, 1941, drought conditions prevailed in eastern Quebec and western New Brunswick while in Prince Edward Island there were frequent and heavy rains. In 1942 the opposite conditions prevailed, eastern Quebec and western New Brunswick had a normal or nearly normal amount of rainfall in June, July and early August while in Prince Edward Island there was a prolonged spring and summer drought. F. M. Cannon, entomologist in Prince Edward Island, reported in late July and again in early August that this aphid was somewhat less noticeable than usual except in one portion of Prince County where a local outbreak developed. Late in the season it became more prevalent and in an autumn report he mentioned 95% of the fields infested with this species.

Table No. 4 shows the records of general field infestation as taken by the collectors of samples, generally experienced potato inspectors or entomologists. These records from numerous places in each province show the nature of the field infestation in August. Considered with the identification of aphid species in the samples as given in Table No. 3 they present a record of the variations during the last three years.

There is at present no direct experimental evidence to prove that the nature of growth of the potato plant, whether retarded by drought or luxuriant in a wet period, has any influence on the rate of development and consequent prevalence of this species of aphid. There are some indications which seem to suggest that climatic features which influence the growth of the potato plant are reflected in the population of the plants by this species of aphid.

Myzus persicae Sulzer was 10% less prevalent in the collections from Quebec in 1942. In the samples from New Brunswick fields there was very little change from the record of the previous year. In Prince Edward Island samples there was a 5% decrease in prevalence. This species may feed anywhere on the potato plant but under field conditions is generally found in greatest numbers on the third lowest quarter of the foliage mass.

The most noticeable changes in field population as shown by the samples was in connection with *Aphis abbreviata* Patch. The samples from Quebec showed a 25% decrease in prevalence. The New Brunswick samples showed a 10% increase while those from Prince Edward Island showed a 24% increase in prevalence.

This species of aphid normally feeds upon the leaves in the lowest quarter of the foliage mass but when numerous may attack any part of the plant. It is generally most prevalent within a two-mile radius of its winter host plant, some one of the species of *Rhamnus* or buckthorn.

The decrease in population as noted from Quebec records may be in part accounted for by recognition of certain localities as centres of infestation and the growing of certified seed stock fields at a distance from these places. (A large proportion of the Quebec collections were from certified seed stock fields.)

In New Brunswick many of the samples were taken from fields in the commercial potato growing regions. It is now known from discoveries made in 1941 and 1942 that the common winter host plant in these commercial potato growing areas is *Rhamnus alnifolia* and that it is present in a number of locations in these regions. Some commercial fields were so heavily infested in 1942 that injury by direct feeding was observed and the plants died down early in August.

In Prince Edward Island this wild host plant has not been discovered but four locations are known where the European buckthorn, *Rhamnus cathartica*, grows and serves as a winter host plant. In each of two years very large numbers of the aphids have been observed ovipositing on these shrubs. In both years the fields within a radius of a mile or more of these locations have been heavily infested with *Aphis abbreviata*, so such places must be considered as centres of infestation for areas of as yet an unknown extent.

The numbers of eggs on both *Rhamnus cathartica* and *Rhamnus alnifolia* vary from year to year as has been learned from counts made on twigs bearing an equal number of buds. In 1941 there were on an average six eggs per bud, in 1942 not more than four per ten buds. The cause for this variation has still to be discovered.

The fourth species, *Myzus pseudosolani*, has been found generally in only a few samples from any province. It has not shown very much fluctuation in prevalence. Its known winter host plant is the garden foxglove which is not generally very hardy and is therefore not widely grown in country districts. It is found in town and village gardens. The aphid is found occasionally in samples taken near such places. An exception is the portion of the Tobique Valley

north-east of Plaster Rock where the flower is popular in gardens and where the aphid is taken from potato plants in moderate numbers.

Through the cooperation of the United States Bureau of Entomology and Plant Quarantine and of the Maine State Experiment Station it was possible to set up and use a type of aphid flight trap devised at the Presque Isle, Maine, Experiment Station for the capture of winged aphids in movement from field to field. A number of these traps were operated during the latter part of July and through August, revealing a number of things concerning the movement of the insects. The captures in these traps confirmed the records of the three previous years that there was a mass movement up the St. John Valley at Perth-Andover in August. One trap, so placed as to catch only the insects which were flying over the water, netted in three days, August 11, 12, and 13, 2092 aphids; of these 590 were *Myzus persicae*, 549 *Macrosiphum solanifolii*, 744 *Aphis abbreviata*. Other traps placed near potato fields caught very large numbers of the winged aphids and provided information concerning the great numbers of the insects moving about in the air in a potato growing region and the relative numbers of the different species. One trap in the Salmonhurst region, Victoria County, in 31 days of operation caught 14,616 winged aphids. Of the potato feeding species *M. solanifolii* made up 5.1%; *M. persicae* 8.9% and *A. abbreviata* 78.4%.

The aphid survey records over a term of years have shown that in certain districts aphids are annually prevalent while in certain other districts they are less so or scarce. With the object of learning more concerning these latter regions visits were made to certain places in New Brunswick and in Quebec during the period of greatest aphid activity in August. These visits showed that at a time when the insects were generally numerous there were places where it was necessary to search carefully to find on potatoes individual aphids. The study of these areas of sparse population would seem to be a desirable feature in connection with future work.

Summary

1. Samples from two hundred thirty-one farm fields of potatoes in the provinces of Quebec, New Brunswick and Prince Edward Island were examined in 1942.

2. The field records made by the collectors of samples showed that the aphid infestation was greater in Quebec and New Brunswick fields, but in Prince Edward Island it was less, in 1942 than it had been in 1941.

3. The detailed analysis of the four samples from each field showed that the observed variation in field infestation was caused particularly by *Macrosiphum solanifolii* Ashmead, the most conspicuous species. This species was present in 11% more of the samples from Quebec, 19% more of the samples from New Brunswick, 22% less of the samples from Prince Edward Island, than in the samples collected in 1941.

4. The theory is proposed that growth conditions in the potato plant as affected by prolonged climatic conditions such as drought, may, over large areas, have an effect upon the field population of *Macrosiphum solanifolii* Ashmead.

5. The examination of samples showed that the field population of the relatively inconspicuous *Aphis abbreviata* Patch was less in Quebec but greater in New Brunswick and Prince Edward Island than in 1941.

6. *Aphis abbreviata* Patch is believed to be an obligate autumn egg-laying aphid which for wintering purposes must find some one of a limited number of shrubbery host plants. Evidence is accumulating to show that the places where these host plants grow are centres from which nearby potato fields became infested. Efforts are being made to locate these centres.

7. The average number of *Aphis abbreviata* eggs per bud or series of buds of a winter host plant in a given location varies from year to year. The cause of this variation is not known but the change is believed to be of economic significance.

8. Aphid flight traps gave definite evidence of the mass movements of flying potato aphids and afforded a means by which it was possible to obtain an estimate of the relative numbers of each species moving on a particular day.

SOME PROBLEMS OCCASIONED BY THE PRESENCE OF THE SUGAR-BEET NEMATODE, *HETERODERA SCHACHTII* SCHM., IN SOUTHWESTERN ONTARIO*

By

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and

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The sugar-beet nematode was first discovered in Canada at Glencoe, Ontario, (2) through specimens identified by Dr. G. Steiner, of Washington, in 1931. Since that time no further infestation has been found in the Glencoe district, but in 1939 a beet grower in the Blackwell district, near Sarnia, Ontario, noticed some injury in his field of sugar beets and plants were examined by members of the staff of the Dominion Entomological Laboratory at Chatham. Nematode injury was indicated and Dr. Steiner later confirmed the presence of *Heterodera schachtii* Schm.

In the autumn of 1940 the senior author was asked to devote part of his time to making a survey and general study of the sugar-beet areas in southwestern Ontario in relation to the problem of sugar-beet nematode infection. Since that time this work has been carried on with the co-operation of the junior author, representing the Ontario Department of Agriculture. Acknowledgements for able assistance with annual beet inspection activities are gratefully extended to Messrs. D. A. Arnott and H. B. Wressel, of the Dominion Entomological Laboratory at Chatham, and to Messrs. S. D. Hicks, C. Copeland, J. E. Armand, and D. J. Petty, of the Dominion Plant Protection Division. Mr. H. C. Hartley served as sugar-beet nematode inspector under the supervision of the junior author in 1941.

To date, a total of 18 different fields in the Blackwell area have been found to be infested with *Heterodera schachtii* Schm. These fields all lie within the Blackwell district and are dispersed within an area of approximately 5 square miles. Up to the present time the actual injury to the sugar-beet crop on these

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infested fields in this district has not been very severe. In some fields little or no injury could be noticed, while in others definite bare patches had made their appearance. The presence of this parasite on wild host plants in this region has been recorded elsewhere (1).

As sugar beets moving to the Chatham factory by rail from the Blackwell district would move through the Glencoe sidings it is considered possible that infection might have been brought into the latter district from Blackwell. The solitary field found infested in the Glencoe district is within a stone's throw of the Canadian National Railway weigh station at Glencoe.

As only the one infected field has been discovered at Glencoe all beet growing in this field was prohibited for an indefinite period, the crop was not marketed, and the beets were treated with formalin solution by the officers of the Chatham Laboratory. However, the infestation found at Blackwell has proven to be so much more extensive than the one at Glencoe that a different treatment of the problem seemed both necessary and advisable.

A definite "precautionary area" has been established in the Blackwell district and regulations aimed at trying to improve conditions within the area and also restricting the spread of the parasite to non-infected areas have been issued and put into force through the Ontario Department of Agriculture. Under these regulations the farmers of the Blackwell area may continue to grow and harvest sugar beets but certain precautionary measures must be followed strictly.

The "precautionary area" established in the Blackwell district has been defined as the area bounded on the north by Lake Huron, on the east by the St. Clair River, on the south by the Sarnia-London highway (No. 7), and on the west by the Brigden side road. This encloses an area of something like 14 square miles and leaves a safety margin of at least $\frac{3}{4}$ of a mile beyond the most outlying infestation. The regulations adopted for this area have been framed with the twofold object of (*a*) reducing the nematode population, and injury, in fields already infested, and (*b*) preventing the spread of these nematodes to sugar-beet areas not yet infested, wherever they may be.

When sugar-beet nematode infestation is discovered in a field the regulations require that the farmer concerned shall not grow sugar beets again in this field until a suitable rotation of crops, approved by the Ontario Department of Agriculture, has been followed. Whether infestation has been reported or not, under no circumstances shall sugar beets be grown immediately following sugar beets on any farm within the precautionary area.

It must be admitted that the problem of crop rotation in the Blackwell area is a difficult one as many of the farms are small and the tendency is to plant a cash crop on as much of the land as possible every year. In addition to sugar beets the planting of potatoes is popular. Onions appear to do well, but injury from onion thrips has been a discouraging factor. In at least the central part of the district (infected) grains are not grown extensively and very little land is left in meadow for hay production. (The Department of Field Husbandry of the Ontario Agricultural College has assumed the responsibility for the design of crop rotations that will fit into the farm economy of the region.)

All sugar beets harvested in the precautionary area are treated as infected beets whether they are known to be actually infected or not. Delivery of these beets is restricted to two weigh stations, both of which lie within the precautionary area, and no beets may be trucked to any point outside of this area.

Furthermore, sugar beets harvested outside the precautionary area may not be trucked into this region. All wagons or trucks used for the transportation of sugar beets to the weigh stations must have tight bottoms and sides and overloading is guarded against. All the above is designed to keep beets, soil and other refuse off the roads and sidings.

At the weigh stations the sugar beets are loaded into railway ballast cars. Through the co-operation of the Canadian National Railway, railway cars are provided for the Blackwell area that will retain the beets and soil and yet be of such construction that they may be washed readily after delivery of the sugar beets. This washing of the cars (hosing) is done at the factory by the Canada and Dominion Sugar Company, after the beets are unloaded. All railway cars carrying sugar beets from the precautionary area are clearly marked with a special red tag. This is the sole channel through which sugar beets move out of the precautionary area.

The water used for washing the railway cars at the factory is finally discharged into a large banked up settling basin which receives all the water from the factory. Sugar-beet nematode infestation has not yet been located in this basin. A large amount of organic matter settles in the bottom of this basin and, in the absence of surface water in the summer months, considerable heating apparently takes place through the decomposition of this material. This is possibly the explanation for the absence of infection as this heating is likely great enough to destroy most or all of the nematode cysts.

The production of beet seed and stecklings is no longer permitted anywhere within the precautionary area. Thus the danger of transporting the infection from place to place on sugar-beet seed is avoided.

Cabbages and cauliflowers are recorded as popular host plants of the sugar-beet nematode. The growing and marketing of these crops in the precautionary area is not restricted, as there would be little likelihood of soil and roots being harvested and shipped with these plants. However, an attempt is being made to restrict the movement out of this area of small cabbage and cauliflower plants intended for transplanting. Soil, roots, and possibly nematode cysts, could be transported in this way and set up infection in new areas. For the same reason the movement of top soil out of the area for use on lawns and gardens is discouraged as much as possible.

During the course of normal farm operations there is always the danger of infested soil finding its way from field to field and from farm to farm. Attempting to regulate this feature is naturally difficult, but the attention of the growers has been drawn to this danger and, as far as possible, they are expected to take all reasonable precautions to prevent the movement of infected material on wagon wheels, farm implements, animal's feet, their own shoes, etc.

Besides attempting to provide specific information on the measures being adopted against sugar-beet nematode infestations in the Blackwell area for the interest of those having similar problems to face, it is hoped that this outline may help to alleviate some of the anxietv which may exist in the minds of others engaged in sugar beet production and who might naturally be interested to hear something about the measures which are being taken to prevent the spread of this pest to new regions.

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A DISCUSSION OF THE PATTERN OF DISTRIBUTION OF THE SUGAR-BEET NEMATODE, *HETERODERA SCHACHTII* SCHM., IN THE BLACKWELL DISTRICT OF LAMBTON COUNTY, ONTARIO*

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The Blackwell district lies about 5 miles northeast of Sarnia, Ontario. Up until 1940 only one beet field in this area was known to be infested with *Heterodera schachtii* Schm., but during the seasons of 1940-42 more detailed studies were initiated with the result that 17 additional beet fields have now been located that show infection. Thus we now know of 18 different fields in this area that are infested with this nematode.

As records of infested fields in the Blackwell area have accumulated the general picture of the distribution of infection has become somewhat clearer. A more difficult further step in this investigation was to try and discover an adequate explanation of this pattern of infection, if one existed.

To date all the infested fields in the Blackwell district have been found occurring in marl soil, some of which border closely or slightly overlap areas of black muck soil. However, a previously reported infested field at Glencoe (1) was in clay soil and, from what is known of this nematode's habits elsewhere, it did not appear altogether reasonable to suppose that this animal confined its activities to marl soil in the Blackwell district through any particular preference. In general, it might be said that this species of nematode has usually appeared capable of thriving in almost any soil that might be suitable for the production of sugar beets. At the same time the possible relationship between infestations and soil type could not be overlooked altogether, and Putnam and Chapman (2) have reported an apparent relationship between soil type and infection by the oat nematode (*Heterodera avenae* Lind, Rostrup, & Ravn, 1913) in the Holland Marsh region lying to the North of Toronto. In the Blackwell region *Heterodera schachtii* Schm. certainly gives the appearance of favoring marl soil, but the writer never felt that definite conclusions on this point were justified in view of all the data available. Because of this belief, active consideration was given to the problem of finding and checking any other possible explanation of its distribution in this area.

As infested fields were discovered in the Blackwell area their locations were carefully plotted on a map of the Sarnia district. While inspecting these fields their location in what appeared to be low regions suggested that this feature of soil levels might be investigated. A contour map of the district was obtained and the contour lines were drawn in on the map showing the distribution

*Contribution No. 2222, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

of infestations. When this was done it could be seen that all infested fields were located below the lowest contour given for the region, *i.e.*, the 600 foot level.

Attention was next given to possible infestations in areas bordering on streams which drained into the Blackwell area. To date the results in this connection have been negative, but this phase of the work will be continued as opportunity permits. However, while making these studies in and around the open drains and the streams, it was noticed that the borders of the drains gave some evidence of overflow at one time or another. It thus appeared likely that the questions of drainage, flooding, and contour levels, were matters that warranted careful consideration.

Most of the Blackwell area is drained by means of large open ditches and in attempting to get a clear picture of the topography of the country it soon became evident that a study of the earlier history of the region was necessary and might prove interesting. Some of the local growers were questioned in this regard and then further data were sought at the Sarnia Library and at the Lambton County Office in Sarnia. From information obtained from these sources it was finally possible to build up a picture of the early conditions in the Blackwell region and also to trace in the outlines of the original water areas of the locality on the field map showing the infested fields.

It appears that about 30 years ago the Blackwell area supported a shallow lake that was known as Lake Wawanosh ("one who steers carefully"). This area has now been drained and the old lake no longer exists. In attempting to visualize the conditions in and around this old lake attention was attracted to a small lake called Lake Chipican located a few miles away on Point Edward. This latter lake apparently gives us a small scale model of what Lake Wawanosh looked like in the early years before the area it occupied was drained. The area actually covered by the water of this small lake was found to be marl soil. Around the lake, however, there is a wide border of black muck soil well covered with plant growth. Beneath this black muck border of the lake marl soil was found. Further checking back to the old lake region of Blackwell seemed to justify the opinion that this same picture presented itself, on a larger scale, in and around the region formerly occupied by Lake Wawanosh. Apparently the old lake bottom was, and still is, marl soil. The wide margins around this lake were covered with black muck soil and would be carrying abundant plant growth.

From the above it was concluded that any flooding that might occur in the Blackwell area would likely be most concentrated in the low area previously occupied by Lake Wawanosh. However, a modification of this conclusion was found necessary. (The original water areas of the Blackwell district are indicated on the accompanying map by stippling. Present rivers and drains are shown by solid black lines.)

A number of farmers owning land covered by black muck soil that lay around the wide margin of old Lake Wawanosh have burnt off this soil to produce land that they considered better suited for the growth of sugar beets. Thus from many of the farms in this area the top covering of black soil has been removed by fire to reveal the underlying layer of marl soil. This black muck covering varies in thickness from 1 - 4 feet or more. Removal of this top layer would result in the lowering of the soil surface level several feet. It thus follows that, as Lake Wawanosh was only around 2 feet deep, any present flooding of the district would tend to spread considerably beyond the margins of the old lake. Or, in other words, flood waters would naturally seek all the present low

areas; which would mean that they would tend to spread over all the surface in this region where marl soil is exposed. It is within this area that all recorded infestations of the sugar-beet nematode have been found.

The drainage system of the Blackwell area ends in a single outlet through which the waters of the drains are discharged into Lake Huron. A large main open ditch, known as the Wawanosh Drain, runs diagonally across the Blackwell district and is fed by a number of large open roadside ditches and a few lateral branch ditches from the fields. The branches of Waddell Creek join to discharge into the Wawanosh Drain and the latter is later joined by a drain lying to the east known as Pulse Drain.

The conditions at the outlet of the Wawanosh drain are interesting. At this point the waters of Lake Huron tend to build up a sand bar which runs completely across the mouth of the drain. This sand block varies in height and width from time to time with the shifting of the sands. However, in the spring of the year the ice from Lake Huron, and from the drain, may pile up on this sand bar to form a rather efficient dam at this point. When this occurs the whole drainage system of the Blackwell region may be temporarily blocked. In the spring flooding would result and the drainage waters of the region would then tend to seek the low areas referred to in our previous discussion.

In addition to the temporary blocking of the drainage outlet which may occur from time to time, the drains themselves are frequently a cause of trouble. Marl soil appears to drain fairly readily but the drains fill up quickly. The roadside drains running through the region most generally infested with *Heterodera schachtii* Schm. are about the worst in the area. This part lies to the west of the Wawanosh drain extending well into the parts where black muck soil has been removed by burning. These feeder drains fill in rather quickly and require re-digging almost every second or third year. (The local inhabitants refer to this soil in these drains as a "quicksand". A cow fell into one of these ditches in 1940 and is still there.)

The origin of the Blackwell infestation is not yet clear and the possibility that this nematode is indigenous to the area must be considered. However, the flooding of the regions referred to above would seem to be an important factor in the spread of nematode infection. It would also greatly improve conditions for human or animal transportation of these plant parasites. Further study of wild host plants, and their life zones is necessary, but, meanwhile, the above tends to provide an explanation that agrees with the known pattern of distribution of this nematode in the Blackwell district.

The root-knot nematode, *Heterodera marioni* (Cornu) Goodey, is very prevalent in the soils of the Blackwell area; more so than the sugar-beet nematode. An interesting point here is that the root-knot nematode shows its greatest concentration in the same low areas as those occupied by the sugar-beet nematode.

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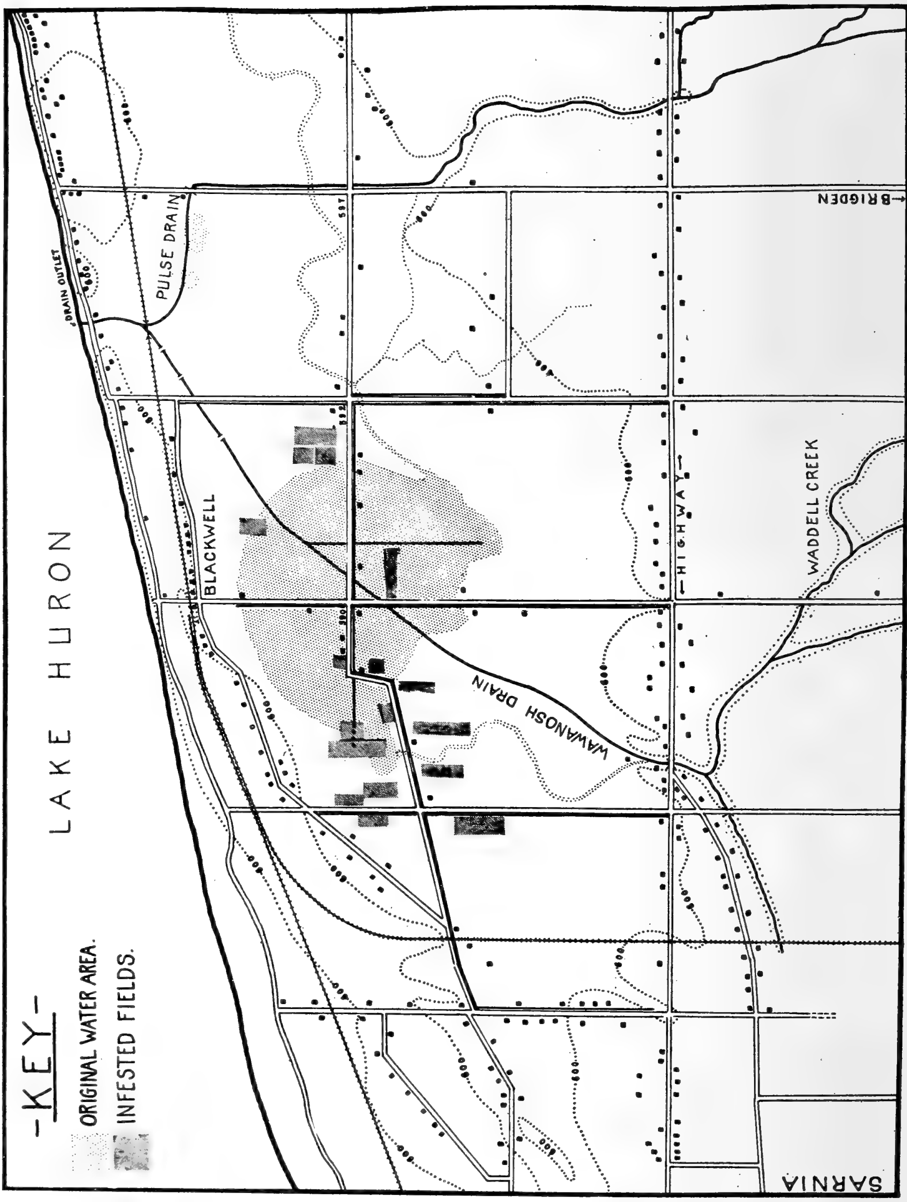

Map showing the pattern of distribution of the sugar-beet nematode, *Heterodera schachtii*, in the Blackwell district, and also the roads, farms, present water drainage system, and the original water areas.

View of Wawanosh Drain in the Blackwell District.

View of Lake Chipican, Point Edward.

NOTES ON THE LESSER PEACH BORER, *SYNANTHEDON PICTIPES* G. AND R., IN ONTARIO*

By Thomas Armstrong

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In all mature peach orchards in Ontario the lesser peach borer, *Synanthedon pictipes* G. & R., may be found feeding in cankers and wounds, the population being especially large in badly cankered trees.

General accounts of this insect in the United States have been given by Girault (3) and King (4). During the past five years a study of the species has been carried on at Vineland Station with special emphasis on the establishment habits of newly hatched larvae. The following notes are the results of this investigation.

Oviposition and Incubation,—The oval reddish-brown eggs are similar to those of the peachtree borer, *Sanninoidea exitiosa* (Say), but slightly smaller, averaging 0.61 by 0.38 mm. They are inserted in cracks and crevices of wounds and cankers on the trunk and branches (Plate I, Fig. 4). In captivity, moths did not oviposit freely on smooth bark, but required crevices in which to hide their eggs. In the orchard the females were attracted to wounded areas for oviposition, but did not deposit eggs in the wet gummy portions.

Efforts to secure eggs in quantity from captive moths met with failure until they were placed in a large cylindrical wire screen cage 15 inches high by 15 inches in diameter (Plate I, Fig. 3) containing a fair-sized cankered peach limb. As many as 50 moths were introduced into this cage during the peak of emergence, and eggs were deposited in large numbers.

The incubation period averaged about 11 to 12 days, with extremes of 9 to 14 days or longer, depending upon the temperature.

Larval Development and Injury,—The larvae hatch during the night and soon bore into the bark tissue. They feed on the inner bark, preferring the callus tissue about the margins of the wounded area. Feeding is accompanied by the exudation of a mixture of gum and castings from the boring. At the approach of cold weather feeding temporarily ceases, and the partly grown borers either stay well down in the channels of the boring, or construct hibernacula of silk and particles of frass in which the winter is spent. The size of overwintering larvae varies greatly, from 4 to 20 mm. in length, the larger being nearly mature. In the spring feeding is resumed until the larvae reach maturity.

The injury to the growing tissues of the tree by borer feeding is extensive, especially since the population is usually large. From a cankered area on the trunk of a medium-sized tree as many as 24 borers have matured in a season. During 1938, 34 caged cankers produced 191 moths, an average of 6 borers in each injured area. The same average was maintained in 1939 from 48 cankers, and in 1941, 35 cankers yielded from 1 to 22 borers with an average of more than 5 per canker.

Pupation,—Pupation occurs from early May until early August at Vineland Station. The mature larva prepares the cocoon very close to the surface of the

*Contribution No. 2209, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

feeding area, so that the pupa prior to moth emergence is able to push its way easily into the open. The cocoon, constructed of pieces of bark and silk, is similar to the larger one of *Sanninoidea exitiosa.*

Time of Adult Emergence,—Moths first appear in the orchards during the latter part of May, and are present until late in August (Fig. 1). During the five years, 1937 to 1941 inclusive, the peak emergence occurred during the week

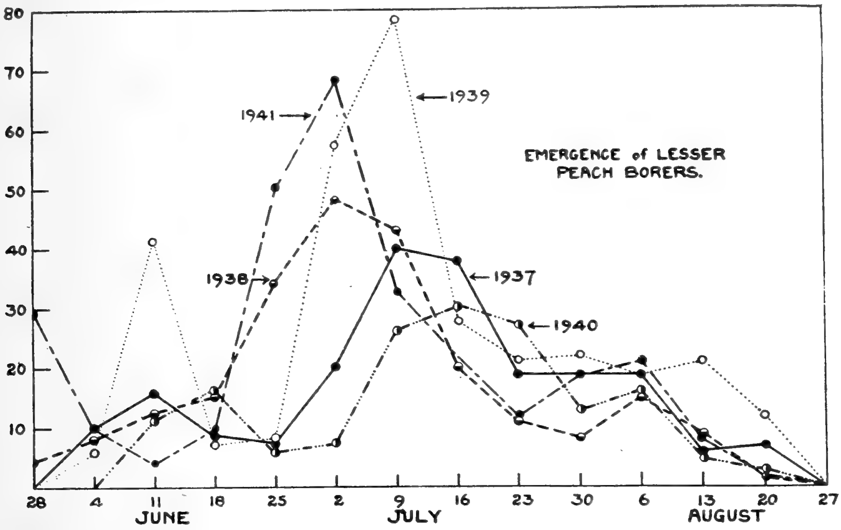

Fig. 1: Weekly emergence records of lesser peach borers at Vineland Station, Ont.

ending July 2 or that ending July 9. The rate of emergence in summary form is presented in Table I. Out of a total of 1208 moths taken in the orchard cages during the five-year period, 48, or 3.9 per cent., emerged during May; 422, or 35.0 per cent., during June; 587, or 48.6 per cent., during July; and 151, or 12.5 per cent., in August.

TABLE 1: SUMMARY OF THE EMERGENCE OF LESSER PEACH BORER MOTHS AT VINELAND STATION FROM 1937 TO 1941 INCLUSIVE

	1937	*1938*	*1939*	*1940*	*1941*	*Average*
First moth emerged	June 1*	May 21	May 29	June 6	May 20	May 20
10% emergence completed	" 10	June 11	June 7	" 14	" 28	June 8
25% emergence completed	" 28	" 23	" 28	July 2	June 23	" 25
50% emergence completed	July 10	July 1	July 6	" 13	" 30	July 5
75% emergence completed	" 22	" 11	" 20	" 23	July 14	" 19
90% emergence completed	Aug. 2	Aug. 1	Aug. 7	Aug. 3	" 31	Aug. 2
Emergence completed	" 18	" 19	" 19	" 18	" 16	" 19
Number of moths observed	210	231	320	160	287	1208

*Approximate date.

Habits of the Moth,—Emergence takes place from 6 to 10 A.M., the time depending largely on the temperature. After resting for about half an hour to

an hour close to the pupal skin while the wings are expanding, the moth is ready to fly. Both sexes, but especially the males, are fast fliers.

Copulation occurs, as a rule, during the day of emergence, very often on the same morning, the male seeking out the female. Coition may last from less than an hour in very hot weather to more than two hours if temperatures are low. In one instance a pair stayed in copula over night but this was the only such occurrence observed in five years. Mating pairs were seen in the orchard usually in the morning hours resting on the trunk or main limbs, and if disturbed would take to flight for short distances while remaining in copula.

Since moths refused to lay when confined individually the actual reproductive capacity of the female was not determined. However from estimates made in the large oviposition cage, and from dissection, a female is capable of laying a large number of eggs. Six females, collected before egg laying and dissected, contained from 232 to 375 fully developed eggs, with an average of 332 per female.

In insectary cages males lived for an average of 9.3 days, and females, 8.8 days, the maximum length of life being 15 and the minimum 5 days. Moths were never seen to feed in the orchard but in the insectary were often observed to extend their proboscis into drops of weak sugar solution or water.

Length of Life Cycle,—The life cycle in the Niagara peach-growing area is completed in one year, that is, the eggs are laid during the summer and development to moths is completed the following season. No records have been secured to indicate that the egg-to-adult cycle can be finished in the one growing season, as is the case in the southern United States. Some individuals may require two years to reach maturity, but no definite proof of this has been obtained. It was observed that 16-mesh wire screen cages did not hinder free moths from depositing eggs either on the cage itself, or through the screening to the cankered peach limb. In 1942, out of 65 caged areas (Plate I, Fig. 5), 22 were found to have eggs laid on the screening or occasionally on the enclosed limb, the moth having passed the ovipositor through the screen. Thus when moths were reared from areas caged for two years, as large numbers were, it was not known whether they had developed from eggs laid by stray moths of the previous year or from eggs placed on the injured branch two years before.

Establishment Habits,—Larvae from eggs of the lesser peach borer placed on canker and wound-free limbs of peach each year from 1938 to 1941 failed to establish themselves. On the other hand, eggs placed in cankered or wounded areas produced moths the following year. During the 1940 season, 726 eggs placed on 15 uninjured peach limbs, did not produce any borers in 1941, but, on the same trees, using the cankered and wounded branches, 48 moths were reared from 1365 eggs. In 1941, a total of 610 eggs placed on 9 clean peach limbs gave rise to no borers, while 58 moths were reared from 1501 eggs placed on 29 cankered or injured areas. On the clean limbs where eggs had been placed, a few small mounds of castings were observed after hatching was completed, but the borings beneath proved to be very shallow, the larvae having died before establishment. In all cases these superficial borings had been made where the roughest bark was present, indicating the preference of the insect for such protection when making entrance to the feeding area.

In 1938 and 1939 moths were reared in greatest numbers from eggs placed on cankered limbs, and poor emergence resulted when the eggs were placed *on* the surface of limbs the bark of which had been punctured with a knife. Protected areas would be more readily available for the newly hatched larvae

on the cankers than on the artificially wounded limbs, which would account for the lower mortality on cankers. By inserting eggs beneath the bark tissue in 1940 and 1941 (Plate I, figs. 1, 2) it was clearly shown that the added protection did result in a greater survival, as shown in Table 2.

TABLE 2: EMERGENCE OF LESSER PEACH BORER MOTHS FROM EGGS IN DIFFERENT SITUATIONS

Position of Eggs	*1941* Number of Eggs Used	Moth Emergence		*1942* Number of Eggs Used	Moth Emergence	
		Total	*Per cent.*		*Total*	*Per cent.*
On clean limbs	762	0	0.0	610	0	0.0
On cankered areas	519	28	5.4	....	....	....
On artificially wounded areas, eggs on surface	337	5	1.5	....	....	....
In artificially wounded areas, eggs inserted under bark	509	15	3.0	1501	58	3.9

The mortality of newly hatched larvae is extremely high regardless of where the eggs are laid, but for maximum survival the young caterpillars need shaded protected entrance areas where the least amount of time is required for them to get beneath the bark surface to their food.

Suggestions for Lowering the Borer Population,—As it has been demonstrated conclusively that larvae cannot establish themselves in healthy unbroken bark it is evident that the control of the lesser peach borer is essentially a matter of keeping peach trees as free as possible from implement wounds, winter injuries and cankers. Canker control as outlined by Willison and Chamberlain (6) calls for (*a*) pruning not earlier than March-April; (*b*) practicing close pruning so as to avoid stubs; (*c*) ceasing cultivation in early July; and (*d*) cutting out not later than the end of June dead wood overlooked at pruning time. Cankers on trunks and main branches may be, and in the case of young trees should be, cleaned and wormed thoroughly in May and June, disinfected with corrosive sublimate (¼ oz. per gallon) and covered with a non-injurious asphalt preparation, or with white lead paste made with a small quantity of boiled linseed oil (turpentine should not be used). Wounds caused by cultivating tools should be avoided.

Winter injury in the form of bark splitting on the trunk makes an excellent area for egg laying and larval development. According to Dr. W. H. Upshall* regulating the amount of nitrogen available to the tree is probably the most important factor in preventing winter injury. By using small quantities of manure fairly frequently, rather than very heavy applications at longer intervals, there will be a more desirable evening up of the nitrogen supply from year to year. If the whole cultivation and fertilization program is such as to insure the proper maturing of the tree before cold weather comes, it will go a long way in preventing this type of injury.

Chemical Control,—Snapp and Thomson (5), working on the lesser peach borer in Georgia, reported a control of 93.4 to 97.9 per cent. when paradichlorobenzene (PDB) dissolved in crude cottonseed oil, ½ lb. to one U. S. quart, was painted on infested areas. Chandler (2) in Illinois also secured good control with PDB dissolved in a tar oil or a miscible mineral oil.

*Chief in Research, Ontario Horticultural Experiment Station, Vineland Station.

In 1933, PDB-cottonseed oil, ½ lb. per Imperial quart, was painted generously on the infested cankers of 60 trees in a Vineland Station orchard in the spring. The results were disappointing as many borers were not killed, and trees were injured, some seriously, by the treatment. In 1937, PDB at the rate of 4 ounces per quart was applied in 50 per cent. emulsions of (*a*) lubricating spray oil, viscosity 170 seconds Saybolt; and (*b*) white oil, viscosity 75-85 seconds Saybolt, unsulphonated residue 96 per cent. These mixtures when painted on cankers caused no injury to the trees, but, as shown in the following table, were ineffective against the borer.

Treatment	*Number of Cankers*	*Moths Emerging*	*Per cent. Control*
PDB-lubricating oil emulsion	20	43	30.0
PDB-white oil emulsion	20	43	30.0
Check, untreated cankers	40	124	0.0

In 1938, PDB-cottonseed oil, ½ lb. per quart, was painted on infested areas in late August but the reduction in emergence was only 48 per cent., 45 moths emerging from 10 treated trees and 87 from the same number of untreated trees.

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Plate I.

Lesser Peach Borer

Fig. 1—Method of inserting eggs beneath bark.

Fig. 2—Artificially wounded limb where eggs have been inserted beneath bark, showing the characteristic signs of larval feeding, frass and gum exudations.

Fig. 3—Oviposition cage.

Fig. 4—Eggs of the lesser peach borer laid in crevices of a canker on a peach limb taken from the oviposition cage. Enlarged.

Fig. 5—Caged areas on a peach tree used in determining establishment habits.

(Photographs by T. Armstrong)

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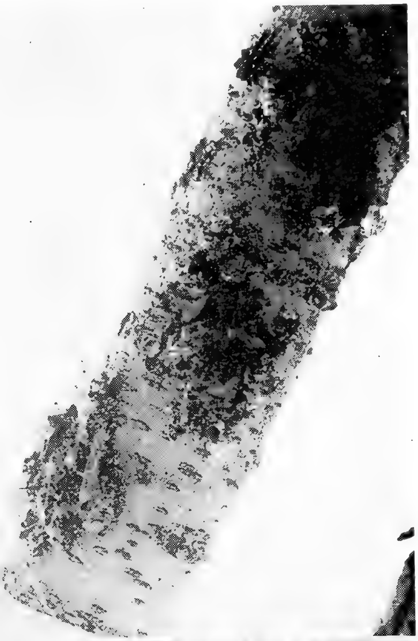

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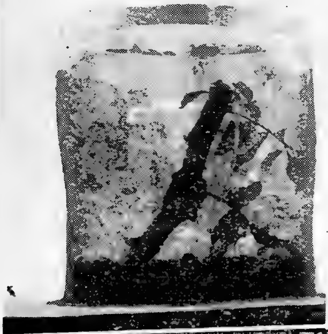

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THE RELATION OF SOME APPLE SPRAYS TO CODLING MOTH PARASITISM BY *ASCOGASTER QUADRIDENTATUS* WESM.*

By H. R. Boyce

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The deleterious effect on several codling moth parasites of spraying with lead arsenate to control codling moth has been reported by a number of workers. Driggers and Pepper (1936) showed that codling moth egg parasitism by *Trichogramma* sp. was greatly reduced in orchards sprayed with lead arsenate and oil as compared with unsprayed orchards. Cox and Daniel (1935) observed that parasitism of codling moth by *Ascogaster carpocapsae* Vier. was reduced greatly in orchards sprayed with lead arsenate as compared with unsprayed orchards. Cox and Daniel also concluded from laboratory experiments that the reduction in parasitism was effected by the poisoning of the adult parasites with lead arsenate. Driggers and O'Neill (1938) indicated that larval parasitism by *Ascogaster* was lower in plots sprayed with lead arsenate than in those sprayed with fixed nicotine or fixed nicotine plus oil. Their plots sprayed with fixed nicotine alone showed the highest percentage of parasitism.

Considerable variation in parasitism by *Ascogaster quadridentatus* in the apple orchards of the Niagara district, has been observed by the writer since the inception of studies of the natural control of the codling moth in 1937, and attempts have been made to determine whether there was any correlation between the spray programme and the amount of parasitism in particular orchards. In addition laboratory experiments were carried out to determine the effect of various spray materials on the longevity and oviposition of *Ascogaster* females.

Field Experiments—During the years 1939 to 1942 a total of 243,323 codling moth larvae was collected from sprayed and unsprayed apple orchards. In making these collections the trees were banded on the trunks with three-ply burlap, six to eight inches in width. These bands were examined several times throughout the season, and the trapped larvae removed and counted. The parasitized larvae being so much smaller than those that are unparasitized, percentages of parasitism were reliably based on this difference in size. Table I shows the results of these counts:

Table I.

Percentage of Parasitism by Ascogaster 1939-1942

Orchard No.	*Treatment*	*Locality*	*Total No. Larvae*	*No. Pars'd.*	*% Pars'sm.*
Year 1939					
1	Unsprayed	Homer	4,908	623	12.7
2	Sprayed	Beamsville	25,800	4,400	17.0
3	Unsprayed	Vineland	6,440	587	9.1
4	Sprayed	Vineland	1,193	156	13.0
5	Sprayed	Beamsville	1,170	92	7.8

*Contribution No. 2214, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Year 1940					
1	No crop				
2	Sprayed	Beamsville	16,210	2,701	16.6
3	Unsprayed	Vineland	6,997	479	6.8
4	Sprayed	Vineland	370	50	13.5
5	No crop				
6	Sprayed	Queenston	1,395	79	5.5
7	Unsprayed	Vineland	5,664	1,076	27.1
Year 1941					
1	Unsprayed	Homer	12,705	877	6.9
2	Sprayed	Beamsville	10,775	1,397	12.9
8a*	Unsprayed	Vineland	10,954	1,914	17.4
8b*	Sprayed	Vineland	1,992	122	6.1
9	Sprayed	Beamsville	40,674	4,520	11.1
10	Sprayed	Vinemount	13,806	797	5.8
Year 1942					
1	Unsprayed	Homer	7,144	1,650	23.1
2	Sprayed	Beamsville	18,308	2,123	11.6
6	Sprayed	Queenston	26,315	756	2.8
8a**	Unsprayed	Vineland	2,666	504	18.9
8b**	Sprayed	Vineland	331	17	5.1
11	Sprayed	Burlington	10,879	832	8.2

*South half of orchard no lead arsenate, but fungicides applied. No sulphur or sulphur compounds used after calyx spray. North half received lead arsenate, 4 covers plus 2¼ to 3% total oil.

**South half received no lead arsenate but Bordeaux ½-1-40 was applied at the time the calyx and first two cover sprays were applied in the north half. The north half received Kolofog, lime sulphur, lead arsenate and DNOC, white oil also was applied with the second, third and fourth cover sprays. The remainder of the sprayed orchards used each year received the regular apple spray programme as recommended in the Ontario spray calendar.

During the years 1939, 1940, and 1941, a comparison between sprayed and unsprayed orchards showed no consistent differences. In 1942, both of the unsprayed orchards had a considerably higher parasitism than any of the sprayed orchards. The differences in timing of spray applications, thoroughness of application, variation in the age of orchards, type of cultivation and orchard surroundings may explain some of the lack of consistent differences in parasitism between the two classes of orchard. Unlike the work of Cox and Daniel, data obtained for the period under consideration suggest a probable rather than definite decrease in parasitism due to spraying practises.

Laboratory Experiments—As consideration of field experiments suggested a possible relationship between the use of spray materials and a frequent low percentage of parasitism, two series of experiments under more controlled conditions were planned.

The first series concerned the effect of lead arsenate and Bordeaux on the length of life of adult parasites. Duplicate lots of parasites were caged, with cube sugar as food, on sprayed and unsprayed potted apple seedlings, or caged with absorbent cotton soaked with the material being tested. In the latter case the control cage contained absorbent cotton soaked with tap water. In tests where the potted seedlings were used the pot and soil surface was covered thus forcing the parasites to secure moisture from the leaf surfaces. Using a small atomizer the foliage was sprayed two to three times daily with tap water. The

cages were kept in a greenhouse compartment operated at 70° to 75° F. Each experiment was repeated several times and the results are presented in Table 2.

TABLE 2.
EXPERIMENTS TO DETERMINE EFFECT OF SPRAY MATERIALS ON LENGTH OF LIFE OF ADULT PARASITES

Treatment	*No. Parasites Used*		*Life Period in Days* *Max.*		*Min.*		*Mean*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Seedlings sprayed with Bordeaux 2-4-40	8	12	10	10	3	3	6.1	5.8
Unsprayed controls	8	12	10	9	4	3	6.3	6.1
Seedlings sprayed with lead arsenate 1½ lb. to 40 gals.	12	10	6	6	4	5	4.9	5.3
Unsprayed controls	12	10	6	6	4	4	4.9	5.0
Cage with cotton soaked with lead arsenate 1½ lb. to 40 gals.	8	8	8	9	5	5	6.1	7.4
Control (cotton soaked with tap water)	8	8	8	9	5	5	6.4	7.1

There was no evidence from the above experiments of poisoning effects of either Bordeaux or lead arsenate, as the length of life in the control groups was not essentially different from the treated lots.

The second series of experiments was made in an outdoor insectary, to determine the effect of several materials on oviposition by *Ascogaster* in codling moth eggs. Duplicate lots of females were caged with apple foliage on which codling moth eggs had been laid the previous day. Sugar and water were kept in each cage to provide food and free moisture so that the parasites need not go to the foliage except to oviposit. One branch was sprayed and allowed to dry before being put in the cage with the females, the other was left unsprayed each day as a control. Each lot of foliage bearing approximately the same number of host eggs was exposed to the parasites for twenty-four hours. This procedure was repeated each day until all the parasites were dead. After the exposure period all eggs were removed from the parasite cages and the number of parasitized eggs determined by dissection, or fixation in Bouin's Picro-formol followed by differential staining with methylene blue. Each material was tested a number of times and the results are given in Table 3.

TABLE 3.
EXPERIMENTS TO DETERMINE EFFECT OF SPRAY MATERIALS ON OVIPOSITION BY *Ascogaster quadridentatus*

Material	*No. Host Eggs Used*	*% Eggs Pars'd on Sprayed Plant*	*% Eggs Pars'd on Unsprayed Plant*
Lead arsenate 1 lb. to 40 gals.	771	48.4	69.6
Lead arsenate 1½ lb. to 40 gals. plus lime sulphur 1 : 50	1944	27.2	75.9
Lead arsenate 1½ lb. to 40 gals. plus lime sulphur 1 : 50 plus wettable sulphur 4 lb. to 40 gals.	1686	8.0	45.4
Lead arsenate 1½ lb. to 40 gals. plus Kolofog 3 lb. to 40 gals.	943	43.7	49.3

The records presented in Table 3 indicate that arsenate of lead alone, or in combination with sulphur fungicides reduced the oviposition of *Ascogaster* females. This reduction was greatest when lime sulphur, or lime sulphur and wettable sulphur together, were added to the lead arsenate. This is of particular interest as it confirms results obtained by Collins (1934) in a study of the effects of orchard illumination and sprays on *Ascogaster carpocapsae*. He says in part "there is the possibility that lime sulphur alone may affect the parasite population, for in the lighted check tree, which received no lime sulphur, the percentage of parasitism was three times greater than in the lighted trees which received lime sulphur but, otherwise, were subjected to the same treatment".

As the longevity of the parasites in both series of tests was essentially the same whether sprayed or not, it would seem that the effect of the spray materials was in the nature of a physical or chemical inhibition of oviposition by the parasites. This might be due to the presence of particles of material on the host eggs or an obliteration or masking of attractive emanations from the eggs.

The present series of experiments was admittedly not extensive enough to give conclusive information regarding the effects of spray materials on *Ascogaster*. However, lead arsenate and lime sulphur appear to have inhibitory effects on oviposition, and further work with these and other spray materials may indicate those which have a limiting effect on the work of this parasite.

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TESTS WITH A PYRETHRUM AEROSOL AGAINST COCKROACHES AND STORED PRODUCT PESTS*

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The use of insecticides in the form of aerosols has recently received considerable attention (1, 2, 3). The employment of a liquified gas as a means of dispersion has been described by Goodhue and Sullivan (4). So far, it would appear, this technique has been used mostly against flies and mosquitoes in the free space of enclosures, such as tents or the cabins of aeroplanes.

The present series of tests was carried out with a proprietary pyrethrum aerosol consisting of 1 per cent. pyrethrins, 2 per cent. oil of sesame and 97 per cent. inert gas, dichlorodifluoromethane, contained in a steel cylinder capable of holding five pounds of the mixture and equipped with a nozzle designed for

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small oil burners. The cylinder was fitted with a siphon tube and discharged two ounces of aerosol per minute.

Indian Meal Moth, Plodia interpunctella Hbn., in Elevator Bins,—In tests against the Indian meal moth infesting wheat in elevator bins filled almost to the top, leaving only 500 to 1000 cubic feet of air space above the surface of the grain, it was found that complete mortality was secured of all adult moths, flying or fully exposed in the free air, with all four doses tested at 2, 4, 8 and 12 ounces per thousand cubic feet. Recently emerged adults, covered with web on the walls of the bins, were only partially controlled, while even at the highest dosage, larvae collected from the webbing on the walls or from the characteristic bundles near the surface of the grain yielded only seven per cent. control. However in this case only, a number of dead larvae were found suspended from the walls and ceiling, thus demonstrating that freely exposed larvae, crawling in the bin, had succumbed to this higher concentration.

This aerosol, therefore, could be employed at a comparatively low concentration at regular intervals to control adult moths flying in storages, and thus prevent their spread to other products in the building. It could not be used to gain control of different stages of the insect when penetration of web, grain or other material is necessitated.

Tests in Steel Vault,—In experiments carried out at 65 degrees F. in an empty airtight steel vault of 1200 cubic feet capacity, 4 ounces of this aerosol per thousand cubic feet was tested against adults of the red flour beetle, *Tribolium castaneum* Hbst. and mature larvae of the dark mealworm, *Tenebrio obscurus* F. The mealworms were placed in glass jars and were unprotected while the beetles were left fully exposed in dishes, or placed in salve tins of two inch diameter pierced at the top with a hole of three quarter inch diameter filled with (*a*) 32 to the inch copper mesh or (*b*) 80 to the inch steel mesh. The insects were placed near the roof or on the floor and the aerosol discharged through a small hole six feet from the floor and one foot from the roof of the vault. In three types of experiment the following results were obtained, after exposure periods of six hours.

(1) *No fan circulation*: Complete control was secured of the fully exposed insects at the bottom of the vault, but no significant mortality was obtained with those near the top or with any of the *Tribolium* adults protected by the mesh.

(2) *Fan circulation*: A fan displacing 625 cubic feet of air per minute was suspended in the vault, and ran continuously during the test. Complete mortality was observed with all fully exposed insects at the top and bottom of the vault, no significant kill was obtained with the protected Tribolium adults at the top, but 59 per cent. and 100 per cent. kills respectively were observed in the 32 and 80 mesh tins on the floor of the chamber.

(3) *Discharge into a partial vacuum*: An initial vacuum of twenty inches (ten inches of absolute mercurial pressure) was drawn on the vault and the hole in the side opened. The aerosol was discharged into the vault in the stream of air entering the chamber until ordinary atmospheric pressure had been obtained. This method was tried to determine if the air being carried into the tins by the dissipation of the vacuum would convey the aerosol in a toxic concentration. This did not appear to be the case, as the mortalities obtained were very similar to those observed with the fan circulation.

From these results it would appear that this aerosol, at a commercial dosage, would not be suitable to control pests in the holds of steam ships and in railroad cars where any degree of penetration into cracks and crevices would be required.

Tests Against the German Cockroach Blattella germanica L.,—In a field test one pound of the aerosol was discharged in a wash room of four thousand cubic feet capacity. This room carried a heavy population of roaches, concealed in the wooden walls which were pierced at intervals with one inch holes to allow diffusion of other types of spray usually employed. As soon as the aerosol was discharged, the cockroaches exhibited the characteristic reaction of running out into the open. After two hours, from a large number of moribund roaches lying on the floor, a representative sample was collected, all of which died within two days. As the concentration of the aerosol built up inside the room, some roaches ran out into the hall outside and 80 per cent. of these succumbed.

After two days the room was treated again with two quarts of a fine kerosene spray containing .224 per cent. pyrethrins and 2.5 per cent. normal butyl carbitol thiocyanate discharged with compressed air at ninety pounds per square inch. This spray had previously been used in the same room and yielded many dead roaches, but on this occasion only a few emerged, demonstrating the effectiveness of the previous aerosol treatment. This spray produced a heavy deposit of kerosene on the floor, and all the roaches inside the room were killed. An interesting comparison was afforded by the fact that the roaches which ran into the hall on this occasion all survived.

The cost of the aerosol and spray treatments would be approximately the same, bearing in mind the extra amount of labour required to assemble and handle the spray as against the higher material cost in the case of the aerosol. In the case of the spray, also, the provision of the compressed air or other dispersing agent must be considered, as well as the inconvenience temporarily caused by the heavy mist and deposit of kerosene.

It is thought that the aerosol could be applied against cockroaches under special conditions, such as places where powders could not be safely or conveniently employed or when control of other insects, such as flies, is desired at the same time. The portability of the aerosol commends it for use in isolated situations.

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A SUMMARY OF THE MORE IMPORTANT CROP PESTS IN CANADA IN 1942

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This summary, prepared from regional reports submitted by officers of the Division of Entomology and members of the Entomological Society of Ontario, deals with the more important field, garden, orchard, and forest pests in Canada during the 1942 season. More detailed statements on these insects, and reports on other species, including such groups as household and stored products insects, insects affecting animals and man, and greenhouse insects may be found in the pages of the mimeographed Canadian Insect Pest Review. Space limitations preclude any detailed reference to them in this article.

Field Crop and Garden Insects

The 1942 season was generally unfavourable to grasshoppers throughout the Prairie Provinces. Wet weather greatly retarded their hatching and development, and produced unusually heavy stands of crops, which suffered comparatively little damage. In Manitoba, the area affected by outbreak numbers of these insects was about 6200 square miles, or less than one-half that of 1941. Poisoned bait was spread in 25 municipalities and losses were light. Fungous disease and adverse weather conditions greatly reduced the grasshopper population except in the Red River Valley and the Interlake District. In Saskatchewan, crop losses were negligible, but, because spring damage was lacking, practically no control campaign was carried on, and considerable egg laying occurred late in the season. At the year's end, most of the prairie area of the province except the southeast was infested generally, if lightly, and the infestation in some restricted areas was moderate to severe. In Alberta, the exceedingly rank growth of crops and grasses furnished an abundant food supply for the young grasshoppers, so that no migrations or damage occurred. The adult stage was not reached until after the majority of the crops were ripe. Some losses were caused to late flax. As in 1941, the most abundant and widespread species in Alberta and Saskatchewan was the lesser migratory grasshopper, *Melanoplus mexicanus* Saus. The clear-winged grasshopper, *Camnula pellucida* Scudder, was important in Manitoba, but comparatively negligible in the other two provinces. Other species involved were the two-striped grasshopper, *M. bivittatus* Say and *M. packardi* Scudder; also the red-legged grasshopper, *M. femur-rubrum* Deg., in Manitoba. The species *Encoptolophus sordidus costalis* Scudder was unusually abundant in several restricted areas in Alberta.

In British Columbia grasshopper numbers reached outbreak proportions over an area extending from the Bulkley and Nechako Valley to the southern Okanagan and Kootenay districts. Although the southern Interior with the exception of the Nicola Valley was particularly heavily infested, little or no commercial damage was done because the lush growth of grass on the ranges produced by the wet season prevented the grasshoppers from migrating into cultivated crops.

The field cricket, *Gryllus assimilis* Fab., was again abundant in the Prairie Provinces, but did comparatively little damage to crops.

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*Contribution No. 2230.

The wheat stem sawfly, *Cephus cinctus* Nort., which caused losses in Saskatchewan and Alberta in 1941 estimated at more than 50,000,000 bushels of wheat, was again present in record numbers, and was probably the most abundant and widespread pest of wheat in Western Canada in 1942. However, losses were not so severe as in 1941, owing to the effects of unusual moisture conditions on crop growth and the sawfly's activities.

The hessian fly, *Phytophaga destructor* Say, was more abundant in southern Saskatchewan than for many years, but vigorous crop growth masked damage, and serious loss was reported only on a small acreage in one locality. Apparently the species was insignificant as a pest elsewhere in Canada.

Say's stink bug, *Chlorochroa sayi* Stal., is widely distributed in Saskatchewan and Alberta, but there were no infestations of economic importance in 1942.

Damage by wireworms, of which *Ludius aereipennis destructor* Brown is one of the most abundant species, although prevalent in the Prairie Provinces, was below average owing to the favourable season which enabled a large proportion of injured plants to recover. Crop loss was comparatively slight in Manitoba, but approximated four per cent. of the wheat crop in Saskatchewan, which is well below average. The damage was most severe to wheat planted on summerfallow in loam soils of the open prairie region. Oats and barley, also, occasionally suffered severely. In southern Alberta, spring wheat was thinned by from five to ten per cent., but winter wheat suffered very little loss except in the Glenwood district. *Cryptohypnus nocturnus* Esch. was the most injurious species in irrigated land, but several other species were also abundant in the province. Increased damage by wireworms was reported in British Columbia where these pests are a problem on vegetable crops.

Cutworms of various species occurred in increased abundance over 1941 throughout Eastern Canada. Vegetable gardens suffered moderate to severe damage in the Maritime Provinces, while in Quebec vegetable and field crops were attacked, including local injurious infestations on tobacco and early canning peas. In the Ottawa district several species occurred in outbreak numbers for the first time in several years. Crop damage in the West was variable and, in general, less than average. The most important infestation was that of the red-backed cutworm, *Euxoa ochrogaster* Gn., and certain other species of this genus, in the park belt of Saskatchewan, where garden plants were attacked and light to moderate damage was inflicted on oats, barley, flax, and, to a smaller extent, wheat. The army cutworm, *Chorizagrotis orthogonia* Grt., was responsible for some crop damage in early spring in southwest Saskatchewan and Southern Alberta, but wet weather enabled the majority of the injured plants to recover. The wheat head armyworm, *Neleucania albilinea* Hbn., which caused considerable damage in some districts of Saskatchewan in 1941, was negligible in 1942. The pale western cutworm, *Agrotis orthogonia* Morr., which was so abundant in Saskatchewan and Alberta in past years, continued to be of very minor importance. In British Columbia, areas which suffered severe damage from cutworms in 1940 and 1941 were comparatively free of these pests in 1942.

White grubs, *Phyllophaga* spp., were a serious pest in parts of Ontario in 1942. The heaviest outbreak, which resulted in very severe losses to field crops, occurred in the County of Hastings and neighbouring counties north of Lake Ontario. Practically all susceptible crops were damaged to some extent, and pastures over large districts in Hastings County were completely destroyed, or largely reduced in value for supporting stock. Fortunately, where the attack was not too severe, good moisture conditions allowed the sod or turf to recover

to a considerable extent after grub feeding had ceased. Another area of heavy infestation was in southwestern Ontario in the counties in the region bounded by London, Brantford and Guelph. The damage to crops was largely caused by second-year grubs and is not expected to recur in the affected regions until 1945. Elsewhere in the Dominion these insects caused light to moderate damage in some areas but, in general, were of little concern.

In Prince Edward Island and Nova Scotia, the Colorado potato beetle, *Leptinotarsa decemlineata* Say, was present in smaller numbers than usual, but increased later in the season to about average importance. The species was scarce on the eastern coastal plain of New Brunswick but very abundant in the western part of the province. Increased abundance was reported in the Richelieu Valley of Quebec: infestation and damage was about average in Ontario. The insect was noted as less abundant than usual in Manitoba, apparently because of winter mortality resulting from scant snowfall. In Saskatchewan it was rarely numerous enough to require control, and in northern Alberta was also reduced and not found in numbers north of Red Deer except in the vicinity of Edmonton: in southern Alberta the usual infestations developed, involving practically every potato patch. In southeastern British Columbia a small infestation was found at Rock Creek, about thirty miles west of Grand Forks, which represents the most westerly point of penetration into the province.

The usual reports of damage by flea beetles were received from every province in the Dominion. Potatoes, tomatoes and cruciferous crops suffered most from their depredations.

Root maggots were injurious in varying degree to cruciferous and onion crops. In eastern Ontario, the cabbage maggot, *Hylemya brassicae* Bouche, was reported to have caused greater loss in early cabbage and cauliflower plantings in market gardens than had been experienced in a quarter of a century.

A further reduction in infestation and damage by the European corn borer, *Pyrausta nubilalis* Hbn., was recorded in Ontario and Quebec. The corn ear worm, *Heliothis armigera* Hbn., was reported as fairly numerous in Nova Scotia and southern Ontario but apparently did not cause serious damage.

Local damage to potato and garden plants was caused in the Maritime Provinces by the tarnished plant bug, *Lygus pratensis oblineatus* Say. Damage was light in Ontario and the species was comparatively scarce in British Columbia.

The hairy chinch bug, *Blissus hirtus* Montd., was prevalent and injurious to lawn grasses at St. Andrews, Sackville and Shediac, New Brunswick. A severe, but local, outbreak of the chinch bug, *B. leucopterus* Say, occurred on corn in Essex County, Ontario.

The sweet clover weevil, *Sitona cylindricollis* Fab., was common and widespread in Ontario, southern Manitoba, and the Wawota and Yorkton-Canora districts of Saskatchewan. In Manitoba there was 50 per cent. loss of the acreage seeded to sweet clover. At least the eastern two-thirds of Saskatchewan are known to be infested.

The beet webworm, *Loxostege sticticalis* L., was of slight importance in Manitoba and Saskatchewan in 1942. It was also greatly reduced in Alberta where, in 1941, it caused severe and widespread damage. In 1942, 1100 acres of beets in the Picture Butte-Turin area were affected, and serious loss to flax and slight losses to alfalfa and garden plants occurred in the Brooks district. The species was fairly common in the interior of British Columbia, but was largely confined to weeds.

A rather severe outbreak of the pea aphid, *Macrosiphum pisi* Kalt., occurred on a thousand acres of soup peas at St. Isidore, in eastern Ontario. This aphid was also common on canning peas locally in Chateauguay County and at other points in southern Quebec. Late canning peas were heavily attacked in the Taber-Barnwell area of Alberta, and it was necessary to apply insecticide dusts to the crop on 800 acres. Widespread and severe infestations of potato aphids were reported in New Brunswick. The so-called green peach aphid, *Myzus persicae* Sulz., was present in 91.4 per cent. of samples from 86 potato fields in this province: *Aphis abbreviata* Patch occurred in 58.7 per cent.

There was apparently a marked decline in the numbers of blister beetles, and no important outbreaks or damage were reported in 1942.

A survey carried out to determine the range of the striped pea weevil, *Sitona lineatus* L., on Vancouver Island, British Columbia, revealed that it has spread along the east coast of the island for 55 miles north of Victoria, and also occurs on Salt Spring Island, the largest island in the Gulf of Georgia. No serious injury to crops has yet resulted from its presence here although considerable damage is reported among field peas in the adjoining State of Washington.

The Mexican bean beetle, *Epilachna varivestis* Muls., which for some years has been known to occur in small numbers in various localities in southern Ontario, was found for the first time in New Brunswick, in August, 1942. Small localized infestations appeared in four counties and may have been established by adults migrating from Maine.

The carrot rust fly, *Psila rosae* Fab., was responsible for considerable damage to carrots throughout Eastern Canada and in British Columbia. Infestations were particularly heavy in the latter province.

The sugar-beet nematode, *Heterodera schachtii* Schm., has now been found in 18 sugar-beet fields in the Blackwell district east of Sarnia, Ontario. Although bare spots were evident in some of the infested fields in 1942, the injury was not severe. The root-knot nematode, *Heterodera marioni* (Cornu, 1879) Goodey, 1932, was much less in evidence in sugar-beets in the Blackwell area in 1942 than in 1941 and 1940. Injury to carrots in this area and at Ottawa was reported. The oat nematode, *Heterodera avenae* Lind, Rostrup & Ravn, 1913, is now prevalent in many areas in southern Ontario between Waterloo and Peterborough. It is not known to occur elsewhere in Canada, and has not yet been reported from the United States. The meadow nematode, *Pratylenchus pratensis* (De Man) Filipjev, 1936, has been found in oats near Uxbridge, Ontario, and the grass nematode, *Anguina agrostis* (Steinbuch, 1799) Filipjev, 1936, was identified from two species of grasses collected near Yarmouth, Nova Scotia.

Fruit Insects

The codling moth, *Carpocapsa pomonella* L., continues to be the most serious pest of apples in Canada. In Nova Scotia, where until a few years ago it was of minor importance, it is now particularly troublesome in central and eastern Kings County and parts of Hants County. There was probably little change in the infestation in centres that have had the heaviest infestations in past years, such as Berwick, but outlying districts showed some increase. Increased damage was also reported in southern Quebec. In southern Ontario injury by larvae of the first-brood was light, but the second-brood caterpillars, large numbers of which entered the fruit during the latter part of August and early September caused serious damage. Injury was lighter than in previous years in eastern Ontario. In British Columbia damage was not so heavy as

had been expected, perhaps because the development of the species was retarded by cool weather. In orchards that received the recommended sprays, crop damage averaged about five per cent.

An increase in the infestation of the apple maggot, *Rhagoletis pomonella* Walsh, was noted in Nova Scotia and Ontario. The increase in Nova Scotia was slight, but involved both the numbers of insects in unsprayed orchards and the number of infested orchards within the spray zone. In Ontario, where a marked decrease was reported in 1941, the number of orchards in which infested fruit could be found increased by about seven per cent. The species continued at a low level in New Brunswick and was of no importance in commercial orchards in Quebec.

No outbreaks of apple aphids were reported in 1942. However, the rosy apple aphid, *Anuraphis roseus* Baker, was fairly abundant in orchards of the Annapolis Valley, Nova Scotia, and caused damage where control was neglected; and the apple aphid, *Aphis pomi* Deg., was more numerous than for several seasons in the Okanagan Valley, British Columbia. Elsewhere these species were comparatively unimportant.

Except for local increases and decreases there was little change in the infestation of gray-banded leaf roller, *Argyrotaenia mariana* Fern., in Nova Scotia. Although reduced in numbers in southern Quebec, as compared with 1941, the fruit tree leaf roller, *Archips argyrospila* Wlk., continued to be of economic importance in the St. Hilaire and Rougemont districts. Damage by it increased at Hemmingford. The species was also injurious in some apple orchards in Ontario.

The eye-spoted budmoth, *Spilonota ocellana* D. & S., was one of the most important apple pests of the season in Nova Scotia and New Brunswick, and was again of major importance in many orchards in Ontario. An increase was noted locally in southern Quebec.

The roundheaded apple tree borer, *Saperda candida* Fab., is present over a wide area in southern Quebec, but has a rather low population in commercial orchards. Light infestations were reported locally in New Brunswick, Ontario. and Manitoba, in 1942. The apple curculio, *Tachypterellus quadrigibbus* Say, and the plum curculio, *Conotrachelus nenuphar* Hbst., have steadily declined in numbers during recent years in southern Quebec, but the latter is still of considerable importance in neglected orchards.

The apple sawfly, *Hoplocampa testudinea* Klug., which was first found in British Columbia in 1940, in the city of Victoria and adjoining municipalities, has not increased its range to any great extent, but appears to have steadily increased in numbers.

In southern Ontario, apple and plum nursery stock was heavily attacked by the potato leafhopper, *Empoasca fabi* Harr., and when not protected the terminal growth suffered injury. There was also a marked increase of the white apple leafhopper, *Typhlocyba pomaria* McAttee, in the province. Moderate numbers of this species occurred in orchards in Nova Scotia.

Damage to nursery stock in the Niagara District, Ontario, and to apple and peach in the Okanagan Valley, British Columbia, by the tarnished plant bug, *Lygus pratensis oblineatus* Say, was much reduced or absent in 1942.

A mealy bug which may be the same species already found on apple in Nova Scotia and British Columbia, namely, *Phenacoccus aceris* Sig., was discovered in small numbers in apple orchards near Thornbury, Ontario.

The European red mite, *Paratetranychus pilosus* C. & F., was scarce in Ontario, but heavy infestations occurred locally in Prince Edward Island, Nova Scotia, and British Columbia. In Nova Scotia the predatory mite, *Seiulus pomi* Parrot, was reported to have destroyed many overwintering eggs by early autumn.

Infestations of the Pacific mite, *Tetranychus pacificus* McG., appeared in late July in several orchards in the Oliver and Kaleden districts, British Columbia. The mite was found for the first time in Kelowna.

The plum nursery mite, *Phyllocoptes fockeui* Nal. & Trt., was present in outbreak form in all plantings of plum nursery stock examined in the Niagara District, Ontario, and caused severe injury.

A moderate increase in the infestation of the oriental fruit moth, *Grapholitha molesta* Busck., occurred in the Niagara Peninsula, Ontario. The first brood larvae were not so heavily parasitized by *Macrocentrus ancylivorus* as in 1941 and favourable conditions of moisture caused a considerable build-up of the second brood. Parasitism of the second brood larvae by *Macrocentrus* was considerably less than in past years, but was augmented to some extent by an increase of parasitism by the native species *Glypta rufiscutellaris.* Injury to the fruit by the late summer fruit moth population was very uneven, generally being higher at points close to the shore of Lake Ontario and in a large portion of the area east of the Welland Canal. In south-western Ontario, the infestation was similar to that of 1941.

The cherry fruitfly, *Rhagoletis cingulata* Loew, has become well established in the Saanich Peninsula, British Columbia, during the past seven years and, in 1942, caused considerable loss of sour cherries.

The pear psylla, *Psyllia pyricola* Foerst, was discovered near Osoyoos, British Columbia, on July 14, 1942. Subsequent surveys revealed that the insect occurs in an area extending from the international border to Penticton on the north and Keremeos on the west. This species hitherto was known to occur only in Ontario, where it was first recorded at Freeman, in 1894, and subsequently became common, especially in the Niagara District; and Nova Scotia, where it has been a fairly common pest since 1903. During 1942, the pear psylla was unusually scarce in the Niagara District, but in Nova Scotia occurred in heavy infestations in eastern Kings and Hants Counties, in some cases causing a considerable reduction in the fruit crop.

The grape leafhoppers, *Erythroneura comes* Say, and *E. tricincta* Fitch, were less abundant in vineyards in the Niagara Peninsula, Ontario, than they have been for a number of years.

Forest Insects

During 1942 there was a further striking reduction in the numbers of the spruce sawfly, *Gilpinia hercyniae* Htg., throughout the areas previously heavily infested in Eastern Canada. The primary cause of this reduction, apart from introduced parasitic insects and other natural control agencies, is the widespread and prevalent larval disease which disposed of so many larvae that heavy infestations virtually no longer exist.

An area of about 40,000 square miles in northern Ontario and western Quebec is heavily infested by the spruce budworm, *Cacoecia fumiferana* Clem. Practically all the balsam and some white spruce has been killed in central Algoma, and heavy mortality has occurred in Algonquin Park and adjacent

areas. Light to heavy infestations are present over much of Quebec, in south-central Ontario, the Spruce Woods Forest Reserve, Manitoba, Banff National Park, Alberta, and in the Kootenay National Park, the Yoho Valley and northwest of Edgewood in British Columbia.

The jack pine budworm, a biological race of *C. fumiferana* Clem., continued to be the most important forest pest in Central Canada. The infestation was particularly heavy in the Kenora and Dryden districts of northwestern Ontario. Throughout this region the outbreak increased in intensity during 1942 and became more widespread, its limits extending eastward north of Lake Nipigon as far as Hearst, Oba, and White River. Increased activity of the budworm was also reported in the Sandilands Forest Reserve and the Riding Mountain Park, Manitoba.

Infestations of the eastern spruce beetle, *Dendroctonus piceaperda* Hopk., of varying intensity have developed in Nova Scotia and northern Ontario. In the former province these occurred along St. Margarets Bay and Mahone Bay, the East River, and the Middle and Baddeck rivers. In Ontario they were reported locally west of Hearst, and on Nighthawk Lake, Remi Lake, and along the highway between Timmins and North Bay. The outbreak of the mountain pine beetle, *D. monticolae* Hopk., in Banff National Park, Alberta, has been largely eliminated by cutting and burning more than 9,000 infested trees. This species continued active around Nixon and Dollyvarden creeks in Kootenay National Park, British Columbia, but a high winter mortality with a resultant drop in the bark beetle population in 1943 was expected.

Throughout Eastern Canada, the larch sawfly, *Pristiphora erichsonii* Htg., was at a low ebb. In Manitoba there were three centres of infestation, namely, at Riding Mountain, Riverton, and the Spruce Woods Forest Reserve. The sawfly was also reported prevalent in a number of other localities in Manitoba, and at Kenora and Hawk Lake, in northern Ontario. This species is now known to occur throughout the larch stands of British Columbia, specimens having been taken for the first time on the western slope of Monashee Range and in the Vernon district, which is about the western limit of larch. Defoliation ranged from light to heavy throughout the infested areas.

Heavy damage to white birch by the bronze birch borer, *Agrilus anxius* Gory, continued to occur throughout a large part of New Brunswick and portions of Nova Scotia. The borer was also present in many of the older stands in Prince Edward Island. Local infestations were reported in Quebec and northern Ontario.

The fall cankerworm, *Alsophila pometaria* Harr., although widespread and abundant in the Prairie Provinces, appeared to be on the decrease in 1942. Heavy defoliation of deciduous trees occurred in many localities, but the damage was alleviated to some extent by the excellent moisture conditions that prevailed throughout much of the affected region. Some defoliation of host trees was reported in southern Ontario and the Maritime Provinces.

The forest tent caterpillar, *Malacosoma disstria* Hbn., continued in outbreak form in parts of northern Ontario, Manitoba, Saskatchewan, and eastern British Columbia, but appeared to be reduced in intensity in the Prairie Provinces. The western tent caterpillar, *M. pluvialis* Dyar, was abundant in northeastern Ontario and northwestern Quebec. Tent caterpillars were not of much importance elsewhere in Eastern Canada.

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Ontario Department of Agriculture

Seventy-Fourth Annual Report

of the

Entomological Society

of Ontario

1943

Printed by Order of

HON. T. L. KENNEDY, Minister of Agriculture

ONTARIO

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1944

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Entomological Society of Ontario

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FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31ST, 1943

Receipts		*Expenditures*	
Balance on hand in Bank	$ 530.92	Printing Canadian Entomologist	$1,048.00
Dues	255.25	Reprinting Canadian Entomologist	116.00
Subscriptions	466.35	Postage	38.77
Advertising	427.60	Bank Exchange	1.88
Back Numbers	57.30	Honoraria & Stenographic Assistance	255.00
Interest & Exchange	21.42	Annual Meeting	2.35
Government Grant	300.00	Miscellaneous	43.17
		Bank Balance	530.37
		Cash on Hand	3.45
	$2,058.84		$2,058.84

Audited and found correct
L. CAESAR
H. W. GOBLE
Auditors

Respectfully submitted
R. W. THOMPSON
Secretary-Treasurer

REPORT OF THE COUNCIL 1942-1943

The seventy-ninth annual meeting of the Society was held in Room 142, Confederation Building, Ottawa, on Thursday, November 12th. Mr. H. G. Crawford occupied the chair. The meeting of the Council was held in the offices of the Division of Entomology, 6th Floor, Confederation Building. During the course of this meeting, at which sixteen papers were presented, forty-two members and visitors were registered.

Because of restricted travelling facilities two regional meetings of the Society were held to supplement the annual meeting. These were held at the Ontario Agricultural College, Guelph, on December 4th, 1942, and at the University of Montreal, Quebec, on December 12th, 1942. At Guelph the Vice-President, Mr. A. B. Baird, occupied the chair and forty members and visitors were present. The programme centred about war problems in Entomology. At Montreal the meeting was an afternoon and evening session of papers, lantern slides and films. Thirty-seven members attended the meeting and twenty-four of these were at the supper arranged in conjunction with it.

We record with sorrow the deaths of Dr. L. S. McLaine and Dr. W. E. Saunders, two outstanding members and past presidents of this Society.

The Council is honoured in expressing appreciation of the services which are being rendered by those members of the Society who are on active service with His Majesty's forces. It is the hope of the Council that they may be spared to soon return to active entomological work.

The journal of the Society, the Canadian Entomologist, completed its seventy-fourth volume in December, 1942. This volume of 236 pages illustrated by 17 plates and 115 figures contained 61 articles, 1 book notice and 15 notes.

These articles were contributed by fifty authors including writers in seven provinces of the Dominion and seventeen states of the Union.

RECORD OF PAPERS PRESENTED AT THE EIGHTIETH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, AT OTTAWA, NOVEMBER 10, AT TORONTO, NOVEMBER 17, AND AT MACDONALD COLLEGE, NOVEMBER 20, 1943.

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"The Influence of Fertility on the Feeding Rate of the Female Tick, *Dermacentor andersoni* Stiles"—J. D. Gregson.

"Hybridization Studies in the Saturniids"—T. N. Freeman.

"A Review of the Japanese Beetle Situation in Canada in 1943"—M. R. Baker.

"Progress Report on Biting Fly Repellent Studies"—C. R. Twinn.

"The Post Discharge Re-establishment Order"—H. W. Jameson.

"The Forest Insect Phase of the Ganaraska Project"—K. E. Stewart.

"The History and Present Status of the Spruce Budworm in Canada"—C. E. Atwood.

"The Role of Forest Management in Forest Insect Control"—J. J. de Gryse.

"The Establishment of Some Imported Parasites of the Larch Case Bearer, *Haploptilia laricella* Hbn., in Ontario"—A. R. Graham.

"The Status of the European Corn Borer in Ontario"—R. W. Thompson

"An Increase in the Multiple Generation of the European Corn Borer in Ontario and Its Relation to Parasite Establishment"—G. Wishart.

"The Status of Insects as a Factor in Grain Storage in Canada"—H. E. Gray.

"Cryptic Species in the Family Chrysomelidae"—W. J. Brown.

"Some Notes on the Taxonomy of Acarid (Tyroglyphid) Mites"—H. H. J. Nesbitt.

"Colour Photography of Some Lepidopterous and Tenthredinid Larvae"—Miss M. R. MacKay.

"Substitutes for Mercury Bichloride in Cabbage Maggot Control"—W. G. Matthewman and J. P. Perron.

"Progress Report on Experiments with Aerosols Under Certain Conditions"—H. A. U. Monro, L. J. Briand, R. Delisle and C. C. Smith.

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"Some of the Problems in Appraising Insecticide Requirements in Canada"—G. F. Manson.

"The Feeding Habits of the White Grubs of *Phyllophaga*"—G. H. Hammond.

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"Work with Substitute Insecticides in Southwestern Ontario"—H. B. Wressell.

"Preliminary Experiments With Dichlor Diphenyl Trichloroethane (DDT) on Several Species of Insects, a Mite and a Crustacean"—G. G. Dustan.

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"Quantitive Studies on the Monarch Butterfly, *Danaus archippus* Fab."—G. Beall.

"Colour Changes in *Mantis religiosa* L."—H. G. James.

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"Multiple Generation *Pyrausta nubilalis* Hbn. on Plants Other Than Corn in Ontario"—G. Beall and G. Wishart.

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REVIEW OF THE JAPANESE BEETLE SITUATION IN CANADA*

By M. R. Baker

Plant Protection Division, Department of Agriculture, Ottawa

In 1939, a dead specimen of the Japanese beetle was intercepted at Windsor, Ontario, in a shipment of cob corn from the United States. The following year the first living beetle taken in Canada was found in a similar shipment of green corn at Montreal.

As this insect gradually approached the Canadian border protective work was started with the object of delaying its entry as long as possible. These activities, which are restricted to the beetle flight season, include the inspection of fruits and vegetables and other commodities from infested areas in the United States; the examination of through cars of freight likely to transport the insect; and the inspection of incoming trucks, buses, automobiles, boats and commercial airplanes.

In 1934, a start was made in the distribution of traps to determine if initial infestation had become established on Canadian soil. The first outbreak in Canada was discovered at Niagara Falls in 1940, and the second outbreak was found at Windsor the following year.

In the spring and fall of 1941, 25 acres were treated with arsenate of lead in Queen Victoria Park at the Falls. The work was carried out in co-operation with the Niagara Parks Commission and the Ontario Department of Agriculture, using the Commission's spray outfit.

After the discovery of the infestation in the City of Windsor, immediate steps were taken to procure a further supply of 10,000 traps for an extensive beetle trapping campaign. Special spray equipment was also purchased for soil control treatment of infested areas.

In 1942, 7,118 traps were placed at strategic points from Windsor, Ontario, to Yarmouth, Nova Scotia. A total of 826 living beetles were trapped during the season in the following fifteen localities: Windsor 616, Riverside 1, Port Burwell 4, St. Thomas 2, Welland 4, Niagara Falls 157, Fort Erie 13, Queenston 1, Hamilton 14, New Toronto 3, Toronto 1, Brockville 4, Prescott 1, Dorval 3 and Westmount 2.

In conjunction with the trapping programme, 242 living beetles were captured at three points during the scouting operations, namely: Windsor 45, Niagara Falls 195 and Fort Erie 2.

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*Contribution No. 35—from the Plant Protection Division, Department of Agriculture, Ottawa.

Altogether, 1,355 Japanese beetles (1,085 alive and 270 dead) were collected from all sources in 1942, and 152.5 acres were either spring or fall sprayed with arsenate of lead, comprising 21.5 acres at Niagara Falls, 117 acres at Windsor, 4.8 acres at Hamilton and 9.2 acres at Fort Erie. Small outbreaks were discovered at the latter two points during the summer.

In 1943, approximately 7,300 traps were set out at 44 localities in 6 different districts from Windsor to Montreal in order to check up on the survival of beetles in the treated locations at Niagara Falls, Windsor, Fort Erie and Hamilton; to determine possible spread; and to ascertain if beetles were penetrating to other points through the medium of common carriers.

No traps were placed at Saint John, Halifax, and Yarmouth this season, because there had been no interceptions of live beetles taken at these ports during the past two years, and the boat service from New York had been discontinued.

As a result of preventive activities in 1943, 219 living beetles were collected: 151 in traps, 37 in scouting and 31 by interception. The trapped beetles were taken at the following nineteen points: Windsor 73, Riverside 2, Brantford 3, Port Burwell 11, St. Thomas 1, London 1, Niagara Falls 16, Fort Erie 13, Welland 1, Toronto 4, New Toronto 5, Long Branch 1, Etobicoke Twp. 4, Mimico 2, Hamilton 9, Brockville 1, Montreal 1, Outremont 2 and Cantic 1. One specimen was captured in scouting at Niagara Falls and 36 were collected in scouting at Windsor, mostly on one infested property. Of the living beetles intercepted, 11 were found at Toronto in carloads of potatoes from Virginia; 18 were found in similar carloads of potatoes at Montreal; and 2 were taken in airplanes at Dorval Airport near Montreal. A total of 840 beetles (219 alive and 621 dead) were collected from all sources during 1943.

It will be noted that less than 1/5 as many beetles were trapped in 1943 as in the preceding year. Similarly, less than 1/6 as many beetles were captured in scouting. Undoubtedly the cool, wet weather of last summer had some influence in checking beetle flight. Nevertheless, it would appear that the marked reduction of the beetle population in the sprayed sections may be attributed largely to soil treatment. There is however, a somewhat disquieting feature presented in connection with beetles trapped this year in untreated localities. Many of these newcomers consisted of single specimens taken in separate traps scattered over a wide area. Quite a number of these specimens were trapped near railway sidings, indicating that they had escaped from carloads of plant products imported from the United States.

New localities in which beetles were trapped this season were: Brantford, London, Mimico, Long Branch and Etobicoke Township, in Ontario; and Montreal, Outremont and Cantic, in Quebec.

Officers of this Division were assisted in Ontario by 30 Farmerette trap attendants in 1942, and 34 in 1943. These girls were provided by the Provincial Department of Agriculture, through the Ontario Farm Service Force organization, and have proved very satisfactory in the performance of their trap line duties.

Soil control operations in 1943 consisted in spring and fall treatments applied to an estimated 75 acres at Windsor. Since the start of the control work, in 1941, approximately 64 tons of lead arsenate have been applied to about 253 acres of ground in infested areas.

So far extensive Japanese beetle activities have been restricted to southern Ontario. Full co-operation by all agencies concerned has been readily supplied; these include the Ontario Agricultural College, the Ontario Fruit Branch and Farm Service Force, the Park and City authorities in the cities where spraying was carried out and the Divisions of Entomology and Plant Protection of the Science Service, Dominion Department of Agriculture.

THE EUROPEAN CORN BORER SITUATION IN ONTARIO IN 1943

By R. W. Thompson

Ontario Agricultural College, Guelph, Ont.

A significant increase in the percentage of stalk infestation by European corn borer occurred in Ontario in 1943. It was not possible to make infestation surveys in all counties of the province where clean-up regulations are in force. As can be seen, however, from the table showing the average percentage of stalks infested by corn borer, for the war years 1939 to 1943, significant increases occurred in 1943 in thirteen of the fourteen counties where counts were made. In some counties there was an increase in stalk infestation of seventy-five to one hundred per cent. in comparison with the figures for 1942. In the remainder of the province, where clean-up measures are not enforced, the increase in stalk infestation was comparable to and in some instances greater than in the clean-up enforcement area.

In spite of the large general increase in stalk infestation there was not the anticipated resultant damage to the corn crop as a whole. Early table corn and early canning corn showed heavy populations of borers in the cobs and considerable injury and loss resulted. The main crop of table and canning sweet corn, however, was not seriously damaged. Field corn was in many cases too late to attract a large number of adults and was therefore less heavily infested than had been anticipated earlier in the season. In practically every field of early corn there was a marked concentration of borers. This condition was noted in fields of hybrid corn as well as in fields of open-pollenated varieties. Since the majority of the corn now grown in the main corn-producing areas of the province is hybrid there was little injury through stalks breaking over. Thus, while early fields of husking corn showed clearly the presence of much increased borer populations, good crops of ears were harvested from these.

The large increase in borer population throughout the province generally resulted mainly from the occurrence of weather conditions which were very favourable to the insect and at the same time very unfavourable to corn growers. Poor weather for fall work occurred in 1942 and therefore a large part of the acreage planted to corn was left to be disposed of until the spring of 1943. The extremely wet weather made disposal of the corn refuse during the spring of 1943 almost impossible, even had growers been able to secure farm help. Many fields were under water continuously until June of 1943. With the acute shortage of farm help clean-up was in many instances incomplete. From observations made in June and July 1943 it is estimated that not more than 65 per cent. of corn refuse in Western Ontario was disposed of satisfactorily. Consequently a much larger increase in population was anticipated in this area than actually occurred. One reason that the anticipated increase failed to materialize fully is explained by the fact that the wet weather retarded the planting of corn in all but a few localities in each county. Thus corn borer moths were limited to a much smaller number of fields than is the case in an average season. Corn for ensilage was planted much later than usual and in the ensilage counties there was a more even distribution of the borer population.

The extremely unfavourable weather at planting time resulted in some decrease in the acreage of corn. This also caused to some extent a concentration of the borer population in earlier plantings of both sweet and field types.

It is of interest to note that in comparison with 1940, when weather conditions were similar to those of 1943, there was a much larger increase in the percentage of stalks infested. The larger increase in 1940 also occurred before the acute shortage of help on farms that occurred in 1943 had developed.

AVERAGE PERCENTAGE OF STALKS INFESTED BY CORN BORER

County	1939	1940	1941	1942	1943
Brant	25.0	63.0	25.0	25.0	38.0
Elgin	40.0	70.0	29.0	33.0	37.0
Essex	29.0	68.0	34.0	31.0	44.0
Huron		46.0	19.0	19.0	34.0
Kent	34.0	73.0	34.0	35.0	45.0
Lambton	38.0	81.0	40.0	36.0	42.0
Lincoln	5.0	39.0	33.0	24.0	17.0
Middlesex	33.0	64.0	29.0	25.0	31.0
Norfolk	27.0	70.0	26.0	18.0	37.0
Oxford	38.0	70.0	22.0	24.0	42.0
Perth	45.0	64.0	25.0	17.0	24.0
Waterloo	25.0	66.0	22.0	20.0	31.0
Welland		35.0	31.0	19.0	30.0
Wentworth	21.0	39.0	28.0	24.0	31.0

FACTORS AFFECTING THE INCREASE IN POPULATION OF THE CORN BORER, *PYRAUSTA NUBILALIS* HBN., IN 1943

By Joseph Duncan

Quebec Plant Protection Division, Montreal

Many factors have contributed to the increase of the European corn borer population this year. Following an investigation which was recently made, it was found that the average degree of infestation for the Province of Quebec had increased from 6.3 per cent. in 1942 to 18.8 per cent. this season. That is to say, the percentage of infestation had tripled.

The principal reasons for this increase of the corn borer population may be attributed to many different causes. The following data have been verified and compiled at the Entomological Station at St. Martin, Laval County:

1.—The clean-up campaign was effected under very unfavourable conditions due to the shortage of labour and the abundance of rain. The cold and rainy spring weather delayed the upward movement of the larvae which had been plowed under the preceding fall, and by the end of June, 10 per cent. of the larvae had not reached the surface of the soil; thus a rather high percentage of corn borers probably escaped in spite of favourable clean-up conditions.

2.—The large quantity of snow and the continued cold weather last winter gave the corn borer a good wintering place. According to figures obtained this spring, we have noted a mortality of 7.5 per cent. in comparison to 60 per cent. the preceding year.

3.—The native parasite of the corn borer (*Laborycus prismaticus*) has also been less active. The degree of parasitism has fallen from 6 per cent. in 1942 to 2.5 per cent. this year.

The inclement weather this spring delayed sowing and the emergence of the corn borer. The adults, which usually take flight in the first two weeks in June, appeared only at the beginning of July. Accordingly, early corn was ravaged by this insect.

4.—However, the delay noted in the appearance of the first adults did not shorten the period of emergence. If in 1942 the flight of adults was effected between June 14th and July 26th, this year this period was extended from July 4th to September 5th, that is, over two months.

Last year, 70 per cent. of the adults emerged between June 27th and July 8th, whereas this summer, during this same maximum period, 58 per cent. only of the adults took flight.

5.—As in the case of emergence, the laying time was also extended. In the years 1940-41-42, the laying period took from two to three weeks, whereas in 1943 it was extended over six weeks. This contributed to the scattering of the corn borer on fields sown at a later date.

6.—This year, we have also observed at our laboratory that the percentage of females was higher than that of males—exactly 54.6 per cent. of females compared with 62.2 per cent. of males the preceding year.

7.—The figures obtained by our insect breeding have enabled us to establish the following data:

Last year a female deposited an average of four masses of eggs, totalling 80 eggs, while we find that during the past season a female deposited 8.5 masses of eggs, totalling 145 eggs. These figures show how prolific the corn borer was during the 1943 season.

8.—This year, the area sown in corn has decreased, while many factors contributed to the increase in corn borer population; hence, the intensity of the infestation.

AN INCREASE IN THE MULTIPLE GENERATION OF THE EUROPEAN CORN BORER IN ONTARIO AND ITS RELATION TO PARASITE ESTABLISHMENT*

By George Wishart

Dominion Parasite Laboratory, Belleville, Ontario

The presence of a partial second generation of the corn borer, *Pyrausta nubilalis* Hubn., in Ontario was noted in a previous paper (5). During the summer of 1943 this assumed such a character as to warrant further notice. In 1922 Crawford and Spencer (3) noted the development of a very small second brood in the earliest corn. Caesar and Thompson, 1931, (2) state "even though a small second generation does sometimes occur in a long warm season, this is so small—much less than one per cent.—that it may safely be considered negligible." Arnott, 1941, (1) in reviewing the subject, states, "For many years the extent to which a second generation developed has apparently been negligible."

Table 1 gives a summary of data secured in the course of parasite recovery studies made along the Detroit River and Lake Erie in Essex County. The development of more than one generation, as indicated by these data, appears definitely to be on the increase and is of such proportions as to indicate that it is not solely the result of warm, long summers, but may be the expression of hereditary or other factors. In other words, if one does not assume that other factors are involved, it would have to be assumed that 1940 had a particularly long warm summer and that those of 1941,

*Contribution No. 2272, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

1942 and 1943 were progressively longer and warmer. This, of course, was not the case. The season of 1943, when the largest second generation was present, was characterized by a singularly late and cold spring.

TABLE 1

Data on Pupation of Borers Obtained from Collections Made in Essex County for Recovery of Introduced Parasites

Year	*Date of collection*	*Average pupation*	*Maximum pupation*	*Point of Maximum pupation*
1940	Aug. 21	3.09%	13.0%	Oxley
1941	July 25	2.25	15.1	Oxley
1942	Sept. 3	9.2	21.1	Leamington
1943	Aug. 3, 4 & 5	13.03	28.3	Leamington

If it is assumed that a hereditary factor is involved, that factor would be one which would produce continuous development, that is, development without an obligate diapause. That this tendency to continuous development was present in a very small proportion of the population early in the history of this pest in Ontario is evidenced by the fact that small numbers of pupating individuals have been found regularly in south-western Ontario, and in warm summers as far east as Belleville. The increase in the proportion which the summer pupating part of the population bears to the whole population in south-western Ontario is probably due to the fact that climatic and crop conditions in this area are more favourable to the development of these multiple generation larvae to maturity than is the case in the other sections where the borer is abundant.

Ample evidence was found that eggs were being laid throughout the greater part of the summer of 1943. In the first week of August, second, third, fourth and fifth instar larvae were found and also freshly formed and emerged pupae. In the last week of September the same stages were found. At Colchester, on Sept. 24, fresh pupae were found in corn which was in the last silk stage. This corn must have been planted much too late to have been oviposited upon by moths from overwintering larvae. Pupae found in this corn would, therefore, be third generation. If this condition continues, the comparative immunity from corn borer attack which has occurred in late planted corn in the past may no longer be expected.

Larvae collected in the early part of August, and which provided the 1943 data in Table 1, were kept at 75°F. in the laboratory. Further pupation amounting to 6 per cent. occurred. At the same time a collection of 200 larvae from the earliest field of corn in the Belleville district was kept under the same conditions. Two emerged pupae were found in this field at the time the collection was made but no further pupation occurred. This means that an average of 13.03 plus 6 per cent. of the larvae from Essex County had the tendency to continuous development while only 1 per cent. of those from the Belleville area had the same tendency. It might be added that this area also provided summer pupae in previous years.

The fact that the area in which the parasite *Lydella grisescens* R.D. is showing the greatest promise is also that in which there is the greatest evidence of the development of more than one generation of the host may be significant. Success of a parasite depends to a large extent on whether or not the host is present in the field in the right stage when the adult parasite is present. *Lydella* emerges normally somewhat in advance of the pupation of the host. Undoubtedly many of the parasites perish before the host appears in the proper stage. Vance (4) states that in Indiana where the borer is developing a multiple generation habit, second generation larvae pupate earlier in the spring than do single generation borers. This is probably also true in

Essex. A more abundant supply of early host larvae will be present on which the parasites may oviposit then if all the borers followed the one generation habit. The parasite has two generations and when only one generation of the borer is present, the second or overwintering generation of the parasite will have to take place on the few late single generation larvae which may be found. Under multiple generation conditions, an abundant supply of suitable hosts is available late in the season. Collections made at La Salle on Sept. 25th in three ages of corn bear this out.

In Table II the larvae collected in late corn would undoubtedly be of the second generation. Parasites forming puparia in the laboratory after collection would have in most cases remained in the host over winter. A much larger overwintering population of parasites is likely to be present where there is a large second generation of the host.

TABLE II

Parasite Recoveries from Three Ages of Corn Collected at LaSalle, Ont., September 25, 1943

Time of Planting	*No. host larvae*	*Lydella puparia*		
		At Time of Collection		*Formed in laboratory later*
		Fresh	*Emerged*	
Early	174	2	14	0
Medium	132	6	9	0
Very late	95	6		25

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MULTIPLE GENERATION *PYRAUSTA NUBILALIS* HUBN. ON PLANTS OTHER THAN CORN IN ONTARIO[1]

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During the summer of 1943, there came repeatedly to the attention of officers of the Dominion Entomological Laboratory at Chatham, Ontario, infestation by *Pyrausta nubilalis* Hubn. of plants other than corn by what appeared to be a multiple-generation strain. The writer is indebted to Mr. C. W. Owen, of the Dominion Experimental Station at Harrow, for calling the situation to his attention. The depredations were of such an unusual nature, for the region concerned, as to be worth reporting. Further, the fairly general occurrence of the corn borer on plants other than maize is characteristic of the multiple-generation New England strain of the insect rather than of the single-generation Ontario strain. That the borer was tending to two broods in southwestern Ontario is apparent from the report of Wishart (1943) for 1942 and the same author informs the present writer that he has evidence, in press, on a further increase in the second brood for 1943. There existed the possibility, however, that

[1]Contribution No. 2276, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

a tendency to multiple-broods might develop in Ontario where Arnott (1942) showed that for many years a limited second generation had probably occurred, without any parallel change in the simple taste (for corn alone), typical of the Ontario single-generation strain.

The evidence of *Pyrausta nubilalis* Hubn. attacking plants other than corn can be summarized very briefly. Potatoes, particularly, were found infested at St. Thomas on August 23 and heavily near Cedar Springs on August 3 and near Harrow, July 26. Soy beans at the Experimental Station, Harrow, were found infested on July 26. Near Chatham, one field of late cabbage was found infested on August 10; some cabbages had been destroyed, but the infestation was not heavy. Mr. George Wishart reports that at La Salle, Ontario, he saw a field of potatoes where eighty per cent. of the stalks were infested. In the fields of potatoes and soybeans, pigweed, *Amaranthus retroflexus* and lambsquarters, *Chenopodium album,* were found to have some boring and occasional larvae. Mr. Wishart reports that, in addition, he found ragweed, smartweed, cocklebur, thornapple and barnyard grass harbouring corn borers at La Salle. In both soybeans and potatoes, the stem was entered just above a node from where the borer tunnelled up. The cabbages were late and had been attacked while still small so that the entire stem was hollow. Mr. A. A. Wood, of the Chatham laboratory, verified the borers as definitely *Pyrausta nubilalis* Hbn.

In connection with the infestation of the soybeans by *Pyrausta nubilalis* Hubn. at the Harrow Experimental Station, a peculiar circumstance should be reported. The beans were not appreciably infested in all of the plots but in 4 plots particularly. In these plots, the infestation in 3 cases was practically restricted to a row on the western edge which was almost completely attacked. In the remaining plot, the infestation was lighter and scattered apparently over one corner. Search failed to show any infestation in 4 other fields of soybeans near the Experimental Station.

The larvae collected on July 26, mainly from soybeans, but to some extent from potatoes, at Harrow, Ontario, and on August 3 at Cedar Springs, Ontario, from potatoes were all of a two-generation strain of *P. nubilalis* as can be seen from the rearing records (due to Mr. H. B. Wressell of the Chatham laboratory) as follows:

Host	*Pupation date*	*Emergence date*	*Host*	*Pupation date*	*Emergence date*
(SB)	July 26*	Aug. 3	(SB)	July 31	Aug. 9
(SB)	" 27	" 4	(SB)	" 31	" 11
(SB)	" 30	" 9	(SB)	Aug. 2	" 11
(P)	" 30	" 9	(SB)	" 2	" 11
(SB)	" 31	" 9	(SB)	" 2	" 11
(SB)	" 31	" 9	(SB)	" 2	" 11
(SB)	" 31	" 9	(SB)	" 2	" 11
(SB)	" 31	" 9	(SB)	" 3	" 11
(P)	" 31	" 9	(P)	" 3*	" 3
(P)	" 31	" 9	(P)	" 3*	" 4
(P)	" 31	" 9	(P)	" 3*	" 5
			(P)	" 3*	" 9
			(SB)	" 4	" 13
			(P)	" 4	" 13
			(SB)	" 6	" 13
			(P)	" 9	" 16
			(P)	" 9	" 16
			(P)	" 9	" 16
			(SB)	" 11	" 18

*Material which had pupated at the date of collection.

It should be added that in the collection on August 3, at Cedar Springs, 10 larvae, 11 pupae and 6 pupal skins were found. It can be seen that the median date of pupation (50 per cent. pupation) was, at latest, August 2 and the median date of emergence about August 9. In collaboration of the foregoing results, Mr Wishart reported that of the borers in potatoes at La Salle, Ontario, as previously mentioned, approximately 50 per cent had emerged as adults on August 5.

It can be seen that in 1943, corn borers attacked, fairly generally, plants other than corn and that all the borers collected under such circumstances were of a multiple-brood type. One other peculiar feature, in the behaviour of the corn borer during 1943, may be put on record, viz., that the adults were seen flying rather freely during the daytime, contrary to all usual experience. They were noticed in numbers all day on July 13, 19 and 24, when sprays were being applied to corn. On July 26, when the previously mentioned observations were made on soybeans, they were also noted flying about and settling on the plants.

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A COMPARISON OF DERRIS AND FIXED NICOTINE IN CONTROLLING THE EUROPEAN CORN BORER BY SPRAYING IN SWEET CORN*

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Introduction—It was demonstrated in 1940 by Stirrett and Thompson (4) that, at least, two insecticides, derris and cryolite, were effective as a spray against the European corn borer under Ontario conditions. Of these two insecticides, cryolite was found to be injurious to the foliage of the corn, while derris is now greatly restricted because of wartime shortages. With this in mind, it was necessary to discover another insecticide which might be recommended for sweet corn spraying.

During recent years, fixed nicotines have been receiving much attention. Commercial preparations of fixed nicotine have been used successfully by orchardists in the United States as summer sprays against the codling moth. Dual-fixed nicotine sprays and dusts have given both favourable and unfavourable results in the United States against the corn borer. Batchelder, Questel and Turner (2) found dual-fixed nicotine to be superior to ground derris. Baker and Questel (1) found derris, especially sprays, to be more effective than dual-fixed nicotine, while Turner (Beard and Turner) (3) showed that a dual-fixed nicotine was consistently better than derris in Connecticut. The experiment that is outlined below was undertaken with a view of testing derris and a fixed nicotine spray under Ontario conditions and on a strictly commercial basis.

Outline of experiment—The field of sweet corn, where the experiment took place, was under contract to the Libby, McNeill and Libby Company, Chatham, Ontario, for canning purposes. The corn, a commercial sweet corn hybrid, was drilled in the row, the rows being 36 inches apart. Three separate treatments of a commercial

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fixed nicotine (5 per cent. nicotine) were used against a single derris (4 per cent. rotenone) spray and a check or unsprayed plot. The nicotine sprays were used in a series of levels, i.e., starting with 6 lbs. per 40 gallons, the dosage was reduced by two-thirds the strength in each of the other two sprays, which were 4 lbs. per 40 gals. and 2 lbs. 11 oz. per 40 gals., respectively. The derris was applied at the rate of 2 lbs. per 40 gals. A commercial spreader of sodium lauryl sulphate was used with the derris; the nicotine was applied without a spreader, according to the manufacturer's directions. Each treatment was replicated twelve times and randomized in six different blocks.

All the sprays were applied by means of a 10-gallon, barrow-type, hand sprayer. The first application was given on July 13, shortly after egg-laying commenced. Two more applications followed, with five-day intervals between. A fourth spray was to have been given, but this was prevented by bad weather. Subsequently, the corn was too high for satisfactory spraying operations. Upon application, all the plant was wet thoroughly, the whorls especially so. The rate of application was approximately 120 gallons (Imp.) per acre.

The ears were picked twice. The first picking was on August 19 and the second on August 26. The picking was done by the company and on the regular commercial basis, supervised by the staff of the Chatham Entomological Laboratory. At the factory, a record was kept of the total ears of each plot as they went up the elevator belt to the husking machine. After going through the husker, the infested ears were sorted from the borer-free ears by company employees. In this way a complete record of ear infestation was obtained from the area under study.

Discussion of results—A summary of the results obtained is given in Table I. It will be observed that derris gave a higher percentage of borer-free ears than any of the commercial fixed nicotine sprays. The two lower concentrations of nicotine, Treatments 3 and 4, were no better than the check plot, Treatment 5. The heavier concentration of fixed nicotine, Treatment 2, did show a higher percentage of borer-free ears than did the check, but it was considerably lower than the derris. Dr. Geoffrey Beall of the Dominion Entomological Laboratory, Chatham, tested the results by the analysis of variance. He found that the derris control was highly significant. Treatment 2 (fixed nicotine, 6 lbs. per 40 gals.), was not clearly significant, while the remaining nicotine sprays did not appear to be significant. All of the plots showed an increase of borer-free ears over the check plot, although the percentage gains, so far as the nicotine sprays were concerned, were not large. These figures may be seen in Table II.

TABLE I. SUMMARY OF RESULTS ON SPRAYING SWEET CORN AGAINST THE EUROPEAN CORN BORER, CHATHAM, ONTARIO, 1943.

Treatment	1 Derris (4% rotenone) 2 lbs./40			2 Commercial fixed nicotine (5% nicotine) 6 lbs./40			3 Commercial fixed nicotine (5% nicotine) 4 lbs./40			4 Commercial fixed nicotine (5% nicotine) 2 lbs. 11 oz./40			5 Check (None)		
	Total No. ears	*No. ears uninfested*	*% borer free ears*	*Total No. ears*	*No. ears uninfested*	*% borer free ears*	*Total No. ears*	*No. ears uninfested*	*% borer free ears*	*Total No. ears*	*No. ears uninfested*	*% borer free ears*	*Total No. ears*	*No. ears uninfested*	*% borer free ears*
1st. Commercial picking, Aug. 19...	3054	2621	86	2674	2180	81.5	2964	2257	74.5	3003	2234	74.5	2682	2049	76
2nd. Commercial picking, Aug. 26..	2098	1813	87	2088	1645	78.5	1898	1461	74	2252	1619	72	1997	1418	71
Totals......................	5152	4434	86.5	4762	3825	80	4862	3718	74.5	5255	3853	73.5	4679	3467	73.5

TABLE II. SHOWING THE GAIN IN BORER-FREE EARS IN SPRAYED PLOTS OVER UNSPRAYED PLOTS OF SWEET CORN.

Gain in borer-free ears............	967				358			251			386			....	
% increase in borer-free ears over check..................	30.5				10.5			9.1			11.1			....	

Summary—Basing the results obtained on ear count alone, and conducting the experiment on a commercial scale, it was shown that derris (rotenone 4 per cent.) was superior to a commercial fixed nicotine spray (nicotine 5 per cent.) in the spraying of sweet corn, under Ontario conditions. Three different concentrations of the nicotine were used, of which one (6 lbs. per 40 gals.), while not clearly significant, indicated that a heavier dosage or a higher percentage of nicotine might give a satisfactory control. The lower concentrations of nicotine (4 lbs. per 40 gals. and 2 lbs. 11 oz. per 40 gals.) were no better than the check or no treatment.

Acknowledgments—The writer is indebted to the Libby, McNeill and Libby Company of Chatham, Ontario, who generously placed their facilities, both in the field and factory, at his disposal. Dr. Geo. M. Stirrett, Entomologist-in-charge of the Chatham laboratory, advised on the preparation of this paper. The randomizing of the plots and the statistical analysis of the data obtained was done by Dr. Geoffrey Beall of the laboratory staff. Field work and the obtaining of experimental data were done by Dr. G. Beall and Messrs. D. A. Arnott, A.A. Wood and H. B. Wressell of the Chatham laboratory.

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THE MEXICAN BEAN BEETLE, *EPILACHNA VARIVESTIS* MULS., IN QUEBEC

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The Mexican bean beetle, *Epilachna varivestis* Mulsant, which has recently made its appearance in the Province of Quebec, is a serious enemy of the bean. Several fields in the counties of Chateauguay, Huntingdon, St. Jean and Brome now harbour this new pest. These fields are located in parishes bordering the States of New York and Vermont.

The manner of introduction of this harmful coccinellid in the Province of Quebec has been a source of comment and it is still to be found. However, a few hypotheses may be mentioned here as a possible means of introduction. First, it was easily possible for the beetle, which is a comparatively strong flier, to fly into the Quebec bean fields situated near the bordering states. The results of the scouting make in several counties has shown that the beetle has followed a valley extending from Rockburn and Franklin down to St. Jean Chrysostome. It is also reasonable to believe that the insect has been carried by shipments of different kinds, but this means of introduction seems to be the least acceptable.

Before taking any steps toward the best way of controlling the new pest, a survey was organized under the supervision of the provincial entomologist, Dr. Georges

Gauthier. About 1200 bean fields and gardens situated about 8 to 10 miles inside the Quebec border line were visited. Of this number, 75 were found infested, in varying degrees, by the Mexican bean beetle.

Following this inspection, which has shown us the importance of the damage already done and the possible danger of propagation for the years to come, it was decided by the authorities of the Quebec Plant Protection Division that every field of beans infested should be burned. Arrangements were made in regard to the damage and losses caused to the owner of infested bean fields.

Oil burners were used to destroy this insect which had the habit of feeding on the underside of the leaves. Different kinds of flame throwers were employed with more or less success. Finally, a special oil burner was made by the Engineering Division of the Department of Agriculture.

This specially built oil burner was mounted on bicycle wheels with an adjustable hood. These burners were installed under the hood, the center one being directed horizontally while the two others were directed toward the surface of the soil. Fuel oil supplied by a 12 gallon tank and preheated in a coil before burning was carried by pressure to the oil burner. Fifty feet of rubber hose was employed from the tank to the machine to facilitate manipulation in the field. This kind of oil burner has given very satisfactory results, the quantity of oil used being about 6 to 7 gallons per hour. With this machine it was possible, under favorable conditions, to burn one acre of beans in four hours. Two men operated the machine.

Now that we have burned every infested bean field, we are taking the necessary measures to study the survival of the beetle during the winter months. A certain number of beetles and pupae were collected from various parts and caged for this purpose.

It is quite possible that we may have to burn some fields again next year, as we expect the insect to cause light and isolated "islands" of infestation.

FURTHER INVESTIGATIONS ON THE VALUE OF MOLASSES-FREE BAITS FOR CONTROL OF CUTWORMS IN TOBACCO FIELDS*

By

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and

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Introduction: The Dominion Entomological Laboratory, Chatham, in co-operation with the Department of Entomology, Ontario Agricultural College, Guelph, and the Dominion Experimental Sub-station, Delhi, made preliminary investigations in 1942 on the use of molasses-free baits for control of cutworms in tobacco fields. The primary object of the work was to determine whether molasses was a necessary ingredient of the standard cutworm bait, composed of bran, paris green, molasses and water. Also, investigations were made on the use of other bait mixtures containing various carriers, poisons and conditioners.

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Review of 1942 investigations: Preliminary experiments conducted in June, 1942, indicated that molasses does not add to the effectiveness of the standard cutworm bait. However, molasses appeared to add to the effectiveness of baits containing sugar-beet pulp and distillers' dried grains, but neither of these mixtures gave as good control as the standard bait without molasses. A commercial preparation, containing some molasses and commonly used as stock food, was much less effective than the standard bran bait without molasses. The poisons, sodium arsenite, sodium fluosilicate and white arsenic appeared as effective as paris green in bran mixtures. A lubricating oil, used in place of water or water and molasses, gave good control when used in bran mixtures with sodium arsenite, sodium fluosilicate and paris green, but was unsatisfactory with white arsenic. A commercial preparation of stock food, without molasses but containing oil, gave little or no control.

Materials tested in 1943: Further experiments were carried out in June, 1943. In these, the use of molasses in the standard bait was again investigated and further tests made with some of the other mixtures used in 1942. Additional materials were also tested as carriers, poisons and conditioners. Three series of bait mixtures were compared. Series I consisted of various conditioners, including water, water and molasses, and oil, which were used in 1942 and, in addition, soybean flour and water, common salt and water in two proportions, and calcium chloride and water. Also, a commercially prepared bait containing bran, sodium fluosilicate and molasses, which is used for cutworm control in New York State, was included in the tests. Series 2 consisted of various poisons, paris green, sodium fluosilicate, sodium arsenite and white arsenic, used in 1942, and in addition, cryolite, ammonium magnesium arsenate and calcium arsenite. Series 3 consisted of a test of various carriers, including bran, distillers' dried grains and a commercially prepared stock food which were used in 1942, and, in addition, fresh sweet clover plants, rolled rye, and ground corn cobs. The various bait mixtures used are given in detail in Table I.

TABLE I. BAIT MIXTURES TESTED IN CONTROL OF CUTWORMS IN TOBACCO FIELDS, DELHI, ONTARIO, JUNE 1943

Treatment No.	
	Series 1. Test of conditioners in bran and paris green mixture
1	Bran, 25 lb.; paris green, 1 lb.; water, 2½ gal.
2	Bran, 25 lb.; paris green, 1 lb.; molasses, 1 qt.; water, 2½ gal.
3	Bran, 25 lb.; paris green, 1 lb.; oil, ½ gal. (lubricating, SAE 30)
4	Bran, 85 lb.; soybean flour, 15 lbs.; paris green, 4 lb.; water, 10 gal.
5	Bran, 25 lb.; calcium chloride, 1 lb.; paris green, 1 lb.; water, 2½ gal.
6	Bran, 100 lb.; sodium fluosilicate, 3 lb.; molasses, 30 lb.; water, 10 gal.
7	Bran, 25 lb.; paris green, 1 lb.; salt, 5½ lb.; water, 2½ gal.
8	(Check) Bran, 25 lb.; water, 2½ gal.
	Series 2. Test of poisons in bran and water mixture
9	Bran, 25 lb.; paris green, 1 lb.; water, 2½ gal.
10	Bran, 25 lb.; sodium fluosilicate, 1 lb.; water, 2½ gal.
11	Bran, 25 lb.; sodium arsenite, 15 oz.; water, 2½ gal.
12	Bran, 25 lb.; cryolite, 1½ lb,; water, 2½ gal.
13	Bran, 25 lb.; calcium arsenite, 1 lb.; water, 2½ gal.
14	Bran, 25 lb.; white arsenic, 9 oz.; water, 2½ gal.
15	Bran, 25 lb.; ammonium magnesium arsenate, 1 lb.; water, 2½ gal.
16	(Check) Bran, 25 lb.; water, 2½ gal.

Series 3. Test of carriers in paris green and water mixture

17 Bran, 25 lb.; paris green, 1 lb.; water, 2½ gal.
18 Distillers' grains, 25 lb.; paris green, 1 lb.; water, 2½ gal.
19 Corn cobs, 25 lb.; paris green, 1 lb.; water, 2½ gal.
20 Comm. stock food, 25 lb.; paris green, 1 lb.; water, 2½ gal.
21 (Check) Bran, 25 lb.; water, 2½ gal.
22 Rye (rolled) 25 lb.; paris green, 1 lb.; water, 1¼ gal.
23 Bran, 25 lb.; paris green, 1 lb.; salt, 1 lb.; water, 2½ gal.
24 Sweet clover (fresh chopped), 25 lb.; paris green, 1 lb.; (no water).

Methods and technique: The 1943 tests were made in the same manner as those of the previous year. Experimental plots were used in typical tobacco fields infested with cutworms on the property of the Dominion Experimental Sub-station, Delhi Ontario. The fields were prepared, the plots baited and tobacco planted, in so far as possible, according to the common field practices of growers in the district.

All mixtures were applied at the rate of 20 lb. per acre (dry weight of carrier), in six replications to randomized plots, 40′ x 40′. Check plots were treated with a mixture of bran and water. Observations on the effect of treatments were made within the central 20 square-foot area of each plot, leaving a buffer area 20 feet wide between plots. Series 1, 2 and 3, of the mixtures, were applied respectively on the evenings of June 2, 3 and 4, between 6:00 and 8:00 p.m. Tobacco was planted six days after baiting. Plant injury counts were taken on each successive day, from the second day after planting to the seventh day, and at intervals of two and three weeks following planting.

Results: The control value of the various baits tested was based on the amount of cutworm injury occurring in the treated plots. The amount of such injury occurring over a three-week period, together with the reduction effected by the treatments at the end of three weeks are given in Table II. These data indicate the effectiveness of the various treatments. The percentage reduction of plant injury obtained by the various baits, as compared with the injury in the check plots, shows the practical value of the treatments in the control of cutworms.

Discussion of results: From the results shown in Table II, it is evident that the addition of molasses to the standard bran and paris green mixture in Treatment 2 did not increase its effectiveness. Treatment 1, the molasses-free mixture, reduced injury 81 per cent., while that containing the molasses gave a reduction of only 57 per cent. Similarly, Treatment 6, which contained molasses, was no more effective than Treatment 1 and much less effective than Treatment 10. Soybean flour appeared to add to the effectivenes of the standard bran bait tested in Series 1, but on the other hand, the standard bait with only water as a conditioner, gave as good control in Series 2 and better control in Series 3.

The other conditioners, calcium chloride, salt at 1 lb. to 25 lb. of bran, and oil, did not add to the effectiveness of the bran and paris green mixture. Salt at 5½ lb. to 25 lb. of bran was decidedly ineffective.

The poisons tested in Series 2 reduced injury in varying amounts from 71 to 94 per cent. The most effective were sodium fluosilicate, cryolite, ammonium magnesium arsenate, and paris green, which reduced injury 94, 92, 90 and 89 per cent. respectively. Arsenic and sodium arsenite were not quite so effective as paris green, while calcium arsenite gave the least reduction in injury, 71 per cent.

Among the carriers tested, bran was the most effective. Treatment 17, in Series 3, reduced injury 100 per cent. Sweet clover and rye were also quite effective carriers, reducing injury 90 and 84 per cent. respectively. Distillers' grain, corn cobs and the commercial stock food were ineffective in reducing injury to an amount of practical value.

TABLE II. RESULTS OF TESTS OF VARIOUS BAIT MIXTURES USED IN CONTROL OF CUTWORMS IN TOBACCO FIELDS, DELHI, ONTARIO, JUNE *1943*

Treat. No.	*Materials tested*	*Percentage plant injury after planting*			*Percentage reduction in injury 3 weeks after planting*
		1 week	*2 weeks*	*3 weeks*	
	Series 1. Test of conditioners in bran and paris green bait				
4	Soybean flour and water	.8	1.6	1.6	88
1	Water	2.2	2.2	2.5	81
6	Molasses and water (commercial bait)	2.0	2.8	2.8	79
5	Calcium chloride and water	2.0	2.5	3.4	75
3	Oil	3.3	3.6	3.6	73
2	Molasses and water	5.3	5.8	5.8	57
7	Salt (5½ lb. to 25 lb. bran) and water	6.2	7.0	7.0	48
8	Check (bran and water)	12.0	12.9	13.4	
	Series 2. Test of poisons in bran and water bait				
10	Sodium fluosilicate	.6	.6	.6	94
12	Cryolite	.8	.8	.8	92
15	Ammonium magnesium arsenate	1.0	1.0	1.0	90
9	Paris green	1.1	1.1	1.1	89
14	White arsenic	1.4	1.6	1.6	84
11	Sodium arsenite	1.6	1.9	1.9	80
13	Calcium arsenite	2.2	2.5	2.8	71
16	Check	9.7	9.7	9.7	
	Series 3. Test of carriers in paris green and water bait				
17	Bran	0	0	0	100
24	Sweet clover (no water)	.8	1.1	1.1	90
22	Rye	1.4	1.7	1.7	84
23	Salt (1 lb. to 25 lb. bran)	1.7	2.0	2.0	81
18	Distillers' grains	4.8	5.0	5.4	50
19	Corn cobs	4.7	5.2	6.0	44
20	Commercial stock food	7.8	7.8	7.8	28
21	Check	9.7	10.5	10.8	

Summary: Tests made in 1943 on the use of various bait mixtures for control of cutworms in tobacco fields showed that the addition of molasses to the standard bran bait does not add to the effectiveness of the mixture. Other materials as conditioners included soybean flour, calcium chloride, salt and lubricating oil. None of these materials, when added to the standard bran bait, was more effective than when water alone was used as a conditioner. Seven poisons tested in the standard bran mixture, were effective in reducing cutworm injury to plants in amounts ranging from 71 to 94 per cent. Of these seven, sodium fluosilicate, cryolite, ammonium magnesium arsenate, and paris green were the most effective. White arsenic and sodium arsenite were quite effective, but did not give as good control as the other four poisons. Calcium arsenite was the least effective. Of six different carriers tested, bran, sweet clover and rolled rye were the most effective. Distillers' dried grains, a commercial stock food, and ground corn cobs were ineffective.

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THE FEEDING HABITS OF *PHYLLOPHAGA* LARVAE*

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Although it is generally known that larvae of *Phyllophaga* feed on the roots, tubers and rhizomes of a wide range of agricultural crops the actual process of feeding, together with the periods by years, are not well known. The popular conception that the grubs swallow considerable soil in feeding, which shows up as a dark mass in

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the posterior part of the body, is largely incorrect. In this short paper is outlined the results of numerous examinations of intestinal contents, together with certain remarks regarding alimentary structures, feeding periods by years, organs used in feeding and related facts, all of which have a direct or indirect bearing on practical control considerations.

The fore-gut and mid-gut in *Phyllophaga* consists principally of a comparatively simple tubular structure, while the posterior main division (hind-gut) consists of a slender anterior tube which enters a large, dark-coloured rectal sac containing waste food materials. Accessory structures, such as malpighian tubules and gastric caecae, are present in these grubs, varying in number and structural design in various species.

Dissections of the intestines of large numbers of white grubs taken from sod and immediately preserved showed that the typical content of all parts of the intestine was small pieces of thread-like fibrous root ranging in length between 0.10 – 4.1 mm., those of 0.50 – 1.0 mm. being representative. In this sod site small fibrous roots were preferred but in other locations with other than a grassy cover the intestine was found to contain partially ground particles of large fibrous roots together with the thread-like fibrous roots. Grubs in hibernation or just prior to entering this period were found to contain no food material anterior to the hind-gut, but with a reduced amount of waste material in the rectal sac.

In all of the dissections of white grubs the marked absence of more than trivial quantities of soil particles was always apparent, regardless of whether the grubs were taken from soil high in organic matter or from sandy soil containing less than 10 per cent. A similar condition was found in the dissection of larvae of *Popillia japonica* Newm., *Diplotaxis brevicollis* Lec., *Polyphaga perversa* Csy, and *Macrodactylus subspinosus* Fab., indicating that the mechanical process of feeding and food selection in case of all of these root-feeding grubs is largely similar.

From the foregoing dissections of grubs of *Phyllophaga* and relatives we have positive evidence that these root-feeding grubs in normal feeding can discriminate between roots and soil. Further, the grubs are evidently capable of shaking or combing off the soil adhering to the roots upon which they feed prior to the food reaching the pharynx, with the assistance of the armature of the 10th ventral segment, the legs and the outer armature of the mouth parts. Sensory organs in the apical segments of antennae, labial and maxillary palpi doubtless assist in the process of food location and cleaning. When the soil is excessively cold or wet and it is difficult to remove the soil from roots grubs feed sparingly or not at all, but under suitable temperature and moisture conditions they feed very rapidly for extended daily periods, causing a great deal of damage to crop roots in a short period which may not immediately be apparent from the condition of the upper part of the plant. In this connection we may point out that grubs and June beetles are seldom found in numbers in soils which become very adhesive when wet or which bake hard when dry.

The process of feeding of grubs in sod occurs normally between a depth one and two inches, where fibrous roots are abundant, the exact depth depending on a number of factors, notably moisture in the surface soil level. Feeding progresses in a narrow, horizontal plane and as plant roots are severed to cause the death of the plant a lateral migration occurs which may progress 100 feet or more in the case of second year grubs which are present in severe outbreak numbers. Grubs are omnivorous feeders and can cut through all but the largest and toughest roots, so that a very wide range of agricultural crops are subject to attack, including a number, like corn, which possess many large fibrous roots. Clovers are known to be resistant to their feeding when established, but extremely resistant crops like alfalfa and sweet clover are readily

killed by white grubs when they are in the seedling stage. Soft tubers like the potato, or large roots like those of the dahlia, are evidently ideal food, often attracting six or more grubs to a single hill, which proceed to excavate large holes in the roots and tubers.

Toward the latter part of the summer in which a second year white grub outbreak is in progress, feeding slows up and then ceases for the season. About this time also, plant re-establishment begins and continues during the following summer. In the process the biennial and perennial plants often make the more certain recovery but annual weeds such as mustard, ragweed and pigweed are first to appear over areas of sod which have been killed by white grubs and may spread very substantially in a short period under the exceptional conditions prevailing. It is very important, therefore, that land which has been seriously ravaged by white grubs should be given immediate attention, not only to prevent wholesale spread of noxious weeds but to avoid natural crop reduction in pasture and meadow. Further, the secondary damage, which may occur for two or more years after the primary damage, consisting of soil erosion or leaching, soil drifting, noxious weed succession and reduced pasture yields, is much more important than generally realized, particularly over farming districts where rotations are neglected.

Although grubs of *Phyllophaga* are present in the soil in each of the three years of the life cycle and feeding occurs over a considerable part of this period, only second year grubs are considered as very serious enemies of crop roots. In the first year the young grubs feed principally in August and September and although ordinarily more numerous per unit area than second or third year grubs, they are small at this time and the short feeding period in the latter part of the summer typically results in only minor crop damage. Prior to going into hibernation in the fall first year grubs cease to feed.

In late April, or early May, of the second year grubs rise from the subsoil to the surface feeding zone and soon begin to feed ravenously. Moulting occurs in early summer and the grubs grow very rapidly after this moult, reaching full size about midsummer. Not only is the attack more widespread than in the case of first year grubs, but it is the period of greatest feeding activity. Areas of dead sod, which indicate the presence of large numbers of white grubs early in the second year, enlarge rapidly to form large areas of brown, dead, detached sod. Pasture areas consisting of 10 or more acres in a block have often been destroyed in eastern Ontario in late years. Usually potatoes suffer severely, especially where planted in green sod of the previous year when second year grubs are present, although the full extent of damage to the tubers cannot be learned until harvest time. Usually in late September, when soil temperatures recede, grubs cease to feed and move downward into the subsoil for the winter where they are largely safe from the effects of late ploughing.

In the third year, as indicated from previous studies*, feeding of the advanced, full-size grubs is confined to less than 25 per cent. of the total individuals present, or those under-developed grubs which did not complete development in the second year. Even for these under-developed grubs, however, the feeding period is of a short duration, extending from about mid-May to mid-June; all resulting in trivial or minor damage to crop roots. After this period individuals reach various inactive stages culminating with the development of the dormant June beetle in late summer of the third year.

White grub infestations follow a three-year cycle of development in Eastern Canada with remarkable regularity, but the cycle or brood in a particular district must be kept in mind, so that particular control methods are applied prior to the occurrence

*Hammond G.H. Ent. Soc. Ont. R. 71 p. 20.

of the destructive second year grub stages. In most of Ontario second year white grub outbreaks in 1945 can be guarded against by applying the shallow-ploughing, multiple-discing control system not later than August of 1944.

WHITE GRUB CONTROL

By Georges Gauthier

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In order to discover certain biological features of a species of June beetle, *Phyllophaga anxia* Lec., prevalent in the Province of Québec, it was subjected to biological and bio-ecological experiments.

Due to the heavy damage caused by this June beetle in certain regions of the Province of Quebec, particularly in the Eastern Townships, an attempt was made to settle on a method of control which would be both effective and also economically practicable for our farmers.

The larvae of this species of June beetle found in the Eastern Townships construct their earthen cells in the upper layers of arable soil, that is, not more than eight inches below the surface of the ground. This is a peculiarity of the species of our regions, as other species studied elsewhere build their earthen cells at different depths. Other peculiarities of the Quebec June beetle consist chiefly in the duration of pupation and the date of its emergence or date of its hatching.

Among the methods of control studied, those consisting of chemical treatments proved to be no more generally practicable against the larvae than against the adults.

The capture of adult June beetles with light traps gave good results as far as numbers were concerned, but presented the disadvantage of selecting the surplus of the male population. Light traps caught over 95 per cent. males which did not seem to have found mates during their period of flight. It is thus easily seen that the destruction of these surplus males would not give a very effective means of control.

A study of a system of crop rotation showed that an appropriate length of the cycle of rotation can, to a certain measure, keep the June beetle in check. Consequently this method may suffice where the soil is only slightly infested, but it is not radical enough for highly infested soils.

The practice of plowing followed by two or three cultivations with a disk harrow considerably reduces the number of June beetles when they are in the larval stage.

We were also able to demonstrate that among man's auxiliaries in the fight against the larvae of the June beetle, the pig has proved to be one of the most efficacious.

The last method of repression that we studied takes advantage of the fragility of the June beetle during its pupal stage, and this consists of extirpating it from its cell with the aid of appropriate farming instruments. After several trials, it was concluded that a deep plowing during the month of July, that is, while the insect is in the vulnerable stage, followed by two successive cultivations with the disk harrow, constitutes the most radical method of control for our region. This method has the great advantage of being simple and inexpensive. We believe that the general application of this method will contribute in a large measure to stemming the plague that this June beetle has become in several regions of Quebec.

FEEDING OF PEA MOTH LARVAE, *LASPEYRESIA NIGRICANA* (STEPH.), WITHIN THE STEMS AND FLOWER BUDS OF CULTIVATED PEAS*

By J. P. Perron

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During the course of investigations of the pea moth, *Laspeyresia nigricana* (Steph.), at New Carlisle, on the Gaspe Coast, P. Quebec, some new information on the feeding activities of the larvae was revealed.

A large study cage, measuring 8 feet long, 4 feet wide, and 6 feet in height, had been erected for life-history studies, etc., of this insect. The soil in this cage had been heavily "seeded" with pea moth cocoons in the autumn of 1939. In the spring of 1940 pea seeds, of the tall telephone variety, were planted inside the cage. This planting was a little delayed and, in addition, the growth, flower blooming and pod formation did not quite keep pace with that of field sowings. Furthermore, our records from this cage showed emergence of some pea moth adults in June, although the peak of emergence did not occur until July 15. The net result was that pea moth

Fig. 1.—Work of the pea moth larvae showing tunnels in the stem. August 1940.

*Contribution No. 2296, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Fig. 2.—Pods injured and distorted as the result of early feeding of pea moth larvae in the flower buds. August 1940.

adults were present in the cage before any pea pods were available for the larvae and there was later evidences of some overcrowding of the insects in relation to the amount of food available. Emergence of some pea moth adults in the field before the blooming of cultivated peas has been observed frequently and hence the conditions existing in our study cage were not altogether unnatural.

It was found that when pea pods are not available the emerging pea moth larvae may travel to the flower buds of the pea plants, bore inside, and start feeding within these buds. This activity was found to result in distorted and sometimes badly injured pea pods. In addition to the above, it was found that these early emerging larvae may also enter and feed within the pea stems. Later in the season some half-grown larvae were found wandering above the pea plants and it is possible that they were driven from the stems to seek food and shelter elsewhere as the pea stems ripened and hardened. The growth and development of these larvae appeared to be affected to some extent by this method of existence.

THE HISTORY AND DISTRIBUTION OF THE PEA MOTH, *LASPEYRESIA NIGRICANA* (STEPH.), IN CANADA*.

By A. D. Baker

Division of Entomology, Ottawa, Ontario

During the years 1936-41, the Division of Entomology of the Dominion Department of Agriculture gave attention to the problem occasioned by the presence of the pea moth, *Laspeyresia nigricana* (Steph.), on the Gaspe Coast. A preliminary report on this work was made by the writer in 1937 (1), and it is now hoped to publish a series of papers dealing with the different phases of the investigations. As a preliminary to reporting on this work an attempt has been made to gather as complete information as possible regarding the history and the distribution of this insect in the various parts of Canada. Many of these records have not been previously reported and some of the earlier observations, particularly those of the late Dr. James Fletcher, seem to have been overlooked by the more recent workers. While records will be given from all parts of Canada special attention naturally will be given to observations on the Gaspe Coast.

Synonyms of *Laspeyresia nigricana* (Steph.) in this country appear to be as follows:— *Pseudotomia nigricana* Steph. 1834; *Semasia nigricana* Fletcher, 1898; *Grapholitha nigricana* Staudinger & Rebel, 1901; *Enarmonia dandana* Kearfott, 1907; *Enarmonia ratifera* Meyrick, 1912; *Laspeyresia dandana* Barnes & McDunnough, 1917; *Laspeyresia nigricana* Barnes & McDunnough, 1917; *Laspeyresia novimundi,* Heinrich, 1920; *Endopisa nigricana* Pierce & Metcalfe, 1922.

In Europe the synonymy of the pea moth still appears to need further elucidation. Some confusion here has been occasioned by lack of careful attention to the different genital characters of *Laspeyresia nigricana* and *L. nebritana*. Each has been listed as a synonym of the other. In reality two distinct species appear to be involved and the *nebritana* of Zeller is a synonym of *nigricana* and not the true *nebritana* of Treitschke. Other names that have been listed as synonyms of *L. nigricana* (Steph.) in Europe include *Laspeyresia non* Teits., *Laspeyresia pisana* Guen. and *Laspeyresia proximana Wilk.* (The generic name of *Cydia* is usually employed for the pea moth in Europe.)

Records of pea moth distribution in Canada were obtained from published works, from reports of the Canadian Insect Pest Survey, from specimens in the Canadian National Collection, from personal observations, and through correspondence with workers in the different provinces.

Early History and Records of Injury

The origin of the pea moth on the North American continent is not definitely known, but it is rather generally believed to be an Old World insect which, by one means or another, has found its way into our midst. Exactly when, where, or how this occurred is not known as definite records are lacking. When the pea moth was first given attention by scientists in this country it appears to have been already rather widely distributed over, at least, the eastern parts of Canada. Thus it is not possible to draw an accurate picture showing the point of introduction and follow this with widening concentric rings to show its subsequent spread from year to year. In these early years biologists were scarce in this country and the early records of the pea moth tend to represent the gradual focusing of scientific attention on this

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insect rather than picturing its spread from some focal point. However, the available records do furnish some ground for the belief that the general direction of dispersal across the continent has been from east to west.

The early history of the pea moth in Canada can not be all gathered from the available literature on the subject. On Prince Edward Island, in Nova Scotia, in New Brunswick, and on the Gaspe Coast, there can be found many oldish farmers who can tell, that, in their boyhood days, pea moth caterpillars were not of infrequent occurrence in the pea pods from the family garden; and some recall having heard their fathers talk of much earlier infestations.

In an article written by Fletcher in 1899 (22), he quotes from a communication he received from a Mr. J. W. Wetmore who, in describing the injury from the pea moth at Clifton in Kings County, New Brunswick, says: "This insect has been injurious here for a period beyond my recollection, some 50 years." This would mean that the pea moth was abundant in New Brunswick as early as 1849. In a previous letter to Fletcher (18) in 1896 the same writer reported that "This insect has existed here at least 40 years, and I can see no appreciable increase or decrease." As early as 1895 Fletcher reported (16) the insect as occurring all the way from "Prince Edward Island to Manitoba," and speaks of it as being present and injurious in Canada "for the past twenty years." Thus the earliest records of the pea moth come from the Eastern Provinces and it is very likely that the insect has been in this country for at least the past 100 years. During these early years, however, the identity of the insect had not been definitely determined, although Fletcher always spoke of it as "The pea moth, *Semasia nigricana*." Chittenden, however, (7) states that the pea moth was first noticed near Toronto in 1893.

In 1894 Fletcher tells us that "maggoty or wormy pease are well known to the house-keeper, but it is seldom that they are sufficiently abundant in gardens to cause much complaint, and I do not think that anything has been yet written in this country upon the life-history of the insect of which these worms are the preparatory stages." He refers to this insect as widely distributed and that it "probably attacks also the seeds of other Leguminosae." It is reported from the seed-pea growing districts of Ontario and also west of Toronto, in Essex County, about Hamilton and London, and also in several places in the Province of Quebec, in Nova Scotia, and as very bad in some parts of New Brunswick and Prince Edward Island. Fletcher also recorded that "seeds of *Lathyrus ochroleucus* and *L. palustris* at East Templeton, Que., were almost entirely destroyed in every pod examined; likewise at Ottawa the seeds of the new fodder plant *Lathyrus sylvestris Wagneri* on this farm and *Vicia cracea* growing wild were seriously attacked." Further reference is made to wild host plants by Fletcher (16) in 1895 when he records that "the seeds of many wild members of the pea family in the woods were also found to be much attacked wherever examined, notably those of *Lathyrus venosus* at Brandon, Man., about half a gallon of pods giving only half a tea-cupful of seed." At the same time he remarks that "I regret to say that so far every one has failed in breeding this pest, so that its identity is still in doubt, and no suggestions of practical value have been made as to remedies." A further report (18) of Fletcher's in 1896 tells us that "the pea moth has again this year attracted a good deal of attention by the extent of its injuries."

In 1897 Fletcher (19) finally had the pea moth successfully identified by Professor C. N. Fernald of Amherst, Mass., from specimens bred from larvae collected the previous year at Ottawa. At this time he reports that injury was "not so marked in Ontario and Quebec as in previous years, but in the Maritime Provinces it has been as widespread as usual." "In Berwick, Kings County, N.S., the pea moth was very destructive to both garden and field peas."

In the first of two papers published in 1898 (20) Fletcher speaks of "much harm at Constance, in Huron County, Ont.," and in his second paper (21) he devotes con-

siderable space to the pea moth telling us that "for many years pease in all parts of Eastern Canada have been much injured and sometimes rendered quite unfit for the table by the caterpillars of a small moth. The large, late garden pease have suffered most. Although its injuries were so considerable, it was only last year the moth was reared and its identity determined. Maggoty pease are well known to the housekeeper; but it is only at intervals of some years that they are abundant enough to cause much complaint." "Last year the attacks of the pea moth upon pease in Ontario were considerable, Mr. John McMillan, M.P. for Huron, even putting the loss at one-third of the crop in his district." In this paper Fletcher gives descriptions of the larva and adult as well as details of the life-history.

In 1899 Lochhead (37) reported that "In Ontario the ravages of the pea-moth appear to be limited chiefly to the counties of Dufferin, Grey, Bruce, and Huron. From a study of its life-history it is very probable that the early varieties will not suffer much from the pest, as the larvae do not appear before the middle of July." In the same year Fletcher (22) says that "The pea moth is still much complained of, particularly in the Maritime Provinces." He further quotes from a letter from Mr. Wetmore, of Clifton, N.B., where he says, "It has, however, come to be such a matter of course with us, that we take its ravages quite philosophically and pick the caterpillars out of our pease for the table; when too bad, we throw the whole mess to the pigs or cows." The following year this same correspondent tried spraying the pea vines when the young pods were forming with a paris green mixture which has been rendered adhesive by the addition of whale-oil soap. The results were not considered conclusive but of a hopeful character. At this time Fletcher (24) again reported that "Much has been done by the caterpillars of the pea moth in the eastern counties of Ontario and extending down through Quebec into the Maritime Provinces. They have been particularly abundant at Ottawa this year in late peas." In a further paper in the same year (25) he speaks of the insect as being "unusually abundant in the Provinces of Ontario and Quebec during the season of 1900. Professor Lochhead reports it as troublesome this season in the northern Counties of Ontario; Grey, Bruce, Huron, Perth, Dufferin and Wellington, but it does not appear to have been quite so destructive in the Maritime Provinces." At Waterford (Norfolk County, Ont.), he says, "There seem to be a few pea moths here—."

A falling off in injury seems to have taken place in 1901 as in this year Fletcher (26) tells us that the pea moth "occurred in some places but not to the same extent as is frequently the case. At Ottawa there were so few of the caterpillars in cultivated peas that some experiments in spraying the plants with arsenites were rendered useless because neither the treated rows nor those left unsprayed as checks, showed any infestation. A plot of the Beach Pea (*Lathyrus maritimus*, Bigelow), however, was badly infested by this insect or an allied species which worked in the same manner and destroyed nearly half the seeds." The following year the same authority (27) again reports the pea moth as being "less destructive than usual." In a second paper (28) in the same year he gives an outline of its distribution when he says it "frequently does a large amount of injury to the pea crop of Canada, chiefly, however, in districts lying east of the area infested by the Pea Weevil and increasing in severity as the Atlantic seaboard is reached."

The pea moth is not again reported until 1905 when Fletcher (29) says "The pea moth seems almost entirely to restrict its attacks to the seeds of wild legumes such as the purple-tufted vetch, the Wild Tare and the Cream coloured Vetchling." He states in a further paper of this year (30) that the pea moth is abundant in Nova Scotia and New Brunswick and also in some parts of Quebec province and in northern Ontario. It is said to be "a regular occurrence in all the Eastern Provinces from the Atlantic seaboard as far as the eastern counties of Ontario. In the Province of Ontario, although sometimes widespread and serious outbreaks occur, they are of

a very intermittent nature and for many years no injury can be detected in cultivated peas. There is, however, in wild leguminous plants a native insect with a very similar caterpillar which is widely distributed through most parts of Canada." At this time the insect occurred so seldom at Ottawa that he experienced difficulty in arranging experiments. In the same article Fletcher records the insect at Beaverton, Ontario, and furnishes an interesting observation indicating the lack of value of an early variety of pea and also of moving pea plantings "more than a mile" away from known infested fields.

Although the pea moth had previously been reported from Manitoba, as indicated in the foregoing account, it was not until 1907 that another definite locality record appeared when a specimen collected from Brandon was identified at Ottawa. This represented the furthest westwardly record of the insect until 1921, when specimens were collected from Nordegg, Alberta, by McDunnough. The pea moth has never been reported from Saskatchewan, but on the other hand, no particular search has been made for the insect in this province. In 1933 McDunnough recovered specimens from Courtney, British Columbia, and in 1934 it was reported from Sumas and Agassiz, in the same province, by Twinn. (46) Thus by 1933 the pea moth had been reported from every province in Canada with the exception of Saskatchewan.

In 1920 Fluke (31) speaks of the pea moth as threatening the pea industry in Wisconsin, where it was to be found "only in the northeastern countries" but "when it first came to Wisconsin, no one knows, but most of the Dore county farmers seem to agree that they first saw the insect about 14 years ago," (1906?) Hanson and Webster (34), however, say that about 1920, "the production of dry peas started to move westward" and the pea moth became of lesser importance in Wisconsin and Michigan after that time, although they record that "the infestations of the pea moth around Lake Michigan and Puget Sound have caused a belief to gain credence that this insect may become numerous only in an area adjacent to a body of water," and that "its general distribution in Northern America and also in Europe indicates an adaptability to the northern part of the United States." Speaking of the infestations in the State of Washington they say the "experienced seedsmen have reported observing injured peas as early as 1926." In its apparent march from the east to the Pacific Ocean the pea moth has paid no attention to national boundaries but rather followed a path ranging on both sides of the international boundary between Canada and the United States. In the eastern United States the pea moth has been present in New York State for an indefinite number of years.

While the records are not complete enough to give a very accurate picture of the abundance and injury caused by the pea moth from year to year, there does appear to be sufficient data available to indicate that there has been considerable variation in this regard from time to time. The earliest records show the insect as causing important damage to crops. (Fletcher 1895, 1898, 1900. Lochhead 1899). However, by 1902 it is interesting to notice that there was a decline in injury that apparently continued through 1905. (Fletcher 1902, 1905). It is not until 1908 that important injury is again reported, when Bethune (2) refers to the pea moth as "troublesome." From here there is a gap until 1911 when Treherne (45) speaks of it as "in evidence" in the Niagara district "but, in numbers not to the same extent as in some years preceding." By 1920 its activities had caused Criddle (11) to speak of the insect as "widespread in Canada as a pea pest." From 1920 on, an increasing amount of attention appears to have been given to the insect in the Maritime Provinces and reports of injury are again frequent. (e.g., Brittain 1920, 1921).

First reports of the pea moth in new regions are often associated with records of important injury. In regions where the insect has become established for lengthy periods there is some indication of a balance being finally set up resulting in decreased abundance and injury to be followed by periodic outbreaks. Hanson and

Webster (34) refer to this feature where they observe that this insect "appears to vary in importance both in North America and in Europe." In the past the pea moth has been classified as an important economic pest in the Province of Ontario and in southern Quebec, but such reports of injury are not now at all common and for the past 15 or more years this insect appears to have become of comparatively minor importance over parts of these provinces where it was previously injurious. However, it is possible that some of its activities may be overlooked, particularly in field peas.

In a later paper, of this series, the writer hopes to discuss the pattern of distribution of the pea moth in this country in relation to host plants and climate.

The Maritime Provinces

In the foregoing portion of this paper dealing with the early history of the pea moth in Canada reference has been made to recorded observations from the Maritimes. Thus Fletcher (15) gives the general record of "P.E.I. to Manitoba" in 1894, and records the insect from the "Maritimes" in 1897, 1899, and in 1900. The same worker also speaks of the pea moth as being distributed in "Eastern Canada" in 1899 and in 1900, and in the "Eastern Provinces" in 1905. The records that follow, from the individual provinces, are thus additions to those referred to above.

General records for "Nova Scotia" are given by Fletcher in 1894, Fletcher in 1905, Brittain in 1920, and Brittain in 1922. Additional and more specific records for Nova Scotia are as follows:—Berwick (Fletcher, 1897); Kentville (Blair, 1897); Smiths Cove (Corr, 1921); Truro (Brittain, 1922); Wolfeville (Spittal, 1924); Truro (Criddle, 1926); Annapolis Valley (Twinn, 1934); Baddeck (Nat. Coll., 1936); Pictou (Pickett, 1938).

General records for "New Brunswick" are those of Fletcher in 1894, Fletcher in 1905, Twinn in 1934, and Twinn in 1935. Additional records from this province are as follows: Clifton (Fletcher, 1896, 1899, 1900); Upper Caraquet (Corr, 1917); Penobsquis (Corr, 1917); River de Caches (Corr, 1921); Fredericton (Gorham, 1929); Fredericton district (Gorham, Walker, & Simpson 1929); Edmundston (Dionne, 1934); Moncton (McLeod 1934); Fredericton (Twinn, 1936); Chamcook (Nat. Coll, 1938); St. Andrews (Nat. Coll, 1938); Kingston, Kings County (Gorham 1890-1900); Alma, Albert county (Gorham, 1942);

In 1894 Fletcher recorded the pea moth from "Prince Edward Island." Records from "Charlottetown" are given by Gorham in 1928, by Clark in 1934, and by Twinn in 1936. Additional records from this province are those from Little York, by Corr in 1916 and from Alberton (Nat. Coll.) in 1940. Mr. F. M. Cannon, of our Division, is stationed in this province and reports this insect as now present in most of his territory where it frequently causes important injury to the pea crop.

The Province of Quebec

For a number of years the pea moth appeared to threaten the continued existence of the green pea industry on the Gaspe coast. Starting in 1936 the Division of Entomology opened up a field laboratory in this region with the primary purpose of giving attention to this problem. At that time the distribution of the pea moth along these coastal ranges was unknown and many of the growers, and others, had the impression that the pea moth was an insect just recently introduced into the area.

The main green-pea growing districts lie between Perce and Grand River, which are all in the County of Gaspe and outside the Bay of Chaleur. Starting in 1934 the production of green peas was extended south-westward to include the St. Godfroi, Shigawake, and Hope Town areas lying in Bonaventure County. Very severe injury

to the pea crop in these latter regions was experienced right from the outset of pea production. Fields with 100 per cent. of the pea pods infested with pea moth caterpillars were not unusual. Discouragement was general and considerable anxiety was exhibited by the pea growers in Gaspe County that this trouble might spread to their county and infest the main green-pea growing areas.

Early surveys of the Gaspe coast soon showed that the pea moth was not a new introduction but rather an insect that had been rather well established in these regions for a great many years. However, it was also evident that the abundance of the pea moth varied very widely in different areas, and definite records were gradually secured that finally established our original supposition that the pea moth could be found throughout all the green-pea growing areas on the Gaspe coast. The next step was to locate the danger spots and move green-pea production from these areas to regions where the pea moth did not cause important injury. To date the main pea growing areas are still in production with relative little injury from the pea moth and even the areas in Bonaventure County are still producing green peas with a greatly lowered percentage of pea moth injury. Much of this improved situation can be attributed to knowledge gained of the climatic factors influencing pea moth abundance and also to an annual vigorous campaign aimed at cleaning up all pea crop remains. Cultural methods of control were also featured.

Lying about 3 miles back from the St. Godfroi-Shigawake-Hope Town shore line, and running parallel to it, there is a shallow sheltered valley situated in the "3rd range" of this region. From 1934-36 inclusive the greater bulk of the green peas from Bonaventure County was produced in this area. However, it was soon observed that this region was particularly favorable for pea moth development, and accordingly green-pea production in this section of the 3rd range was actively discouraged. At the present time pea production in this area has been practically eliminated. Along the shore range of the above district the pea moth sometimes caused injury of importance but it does not approach the intensity of infestation that was experienced on the back range. Green-pea production is continuing on this shore range and with improved farm practices relatively clean crops of green peas have been produced.

By scouting for the pea moth to the south and southwest of St. Godfroi, it was finally possible to link up the infested areas referred to above with infestations in the Province of New Brunswick. Scouting to the north-east proved a more difficult task as the pea moth became increasingly harder to find as soon as one left the regions sheltered by the Bay of Chaleur. However, reasoning from the pattern of infestations in Bonaventure County a search was made for the insect near the head of the Bay of Gaspe with the result that pea moth records were soon secured from Gaspe and from St. Marjorie. These records demonstrated that the pea moth was established to the north as well as to the south of the main pea growing areas in Gaspe County, and there seemed every reason to believe that further careful search would reveal the insect between these points. This conclusion was justified as the pea moth has now been located throughout all the pea growing areas of the Gaspe coast. The abundance of the insect, however, varies widely in the different regions. On the accompanying map of the Gaspe coast the extent and intensity of distribution of the pea moth in the different areas are illustrated. Within these areas there also may be a periodic rise and fall of abundance from time to time.

In the Cape Cove-Perce district (of Gaspe County) the pea moth is usually of minor importance and it is even difficult to find specimens in some years. An interesting parallel is seen in the relative abundance of the Colorado potato beetle, *Leptintarsa decemlineata,* (Say) as this insect does not seem to thrive in this region and it is only in occasional years that insecticidal measures become necessary. Yet as one moves south-west along the coast to approach and enter the Bay of Chaleur

region important and even serious injury from this scource may be observed. The oceanic influences on the climate become greater as one moves to the north-east out of the Bay of Chaleur.

Fletcher recorded the pea moth from the "Province of Quebec" in 1894, 1897, 1900, and 1905. He also recorded the insect as being "through Quebec" in 1900 as well as giving general records for Eastern Canada that have been already noted. The distribution on the Gaspe coast has been dealt with and additional records from Quebec are as follows:—Hemmingford (Hammond, 1925); Aylmer (Walley, 1934, Dustan 1934); Beebe Junction (Baker, 1934); St. Jean (Maltais, 1940); Aubrey and St. Chrysostome (Maltais, ;1941); St. Denis de Kamouraska (Maltais, 1941) Duchesnay (Baird, 1942); Bic, (St. Lawrence) (Gorham, 1942).

The Province of Ontario

The pea moth infestations in the province of Ontario are clearly linked with the infestations in the province of Quebec. This is indicated by our locality records and even in 1895 Fletcher spoke of the insect as being distributed all the way from Prince Edward Island to Manitoba. Chittenden (7) tells us that the pea moth was first observed near Toronto in 1893. Other records of the nineteenth century indicate a wide distribution of the insect in this province at that time. At one time the pea moth was the cause of serious concern in these regions but in more recent reports of severe injury have become much less frequent. A capture by Walley in 1934 at Smoke Falls on the Mattagami River is the most northerly record. This and a capture at Minake, in the Rainy River District, by McDunnough in 1928 tend to link the Ontario infestations with those in the province of Manitoba. Records of distribution are as follows: Toronto 1893 (Chittenden, 1909); West of Toronto, Essex County, Hamilton, London, Ottawa (Fletcher, 1894); Huron County, Constance (Fletcher, 1898); Dufferin County, Grey County, Huron County, Bruce County (Lochhead, 1899); Waterford, Grey County, Bruce County, Huron County, Perth County, Dufferin County, Wellington County (Fletcher, 1900); Ottawa (Fletcher, 1901); Beaverton (Fletcher, 1905); Lindsay (Bethune, 1908); Niagara District, Jordon Harbour (Treherne, 1911); Ottawa (Curran, 1925); Minake (McDunnough, 1928); Loring (Caesar, 1929); Bobcaygeon, (McDunnough, 1931); Merivale (Walley, 1931); Smoke Falls (Mattagami River) (Walley, 1934); Ottawa (Dustan, 1934); Ailsa Craig (O.A.C., 1932).

The Prairie Provinces

The first record of the appearance of the pea moth in the Prairie Provinces apparently dates from 1895 when Fletcher writes of the insect being distributed all the way from "Prince Edward Island to Manitoba."

No special search for the pea moth in these provinces has been made and important injury has not been recorded. It is thus possible that this insect may be more widely distributed in these regions than our records would indicate.

In Manitoba the pea moth was recorded from Brandon in 1895 by Fletcher and again in 1926 by Criddle. Specimens in the National Collection were captured at Berens River in 1938.

The pea moth has not yet been located in the Province of Saskatchewan.

In the Province of Alberta this insect was recorded from Nordegg by McDunnough in 1921 and again by Criddle in 1926. A capture was also made at Edmonton in 1936.

British Columbia

Due to its abundance and the injury to the pea crop in the Lower Fraser Valley caused by this insect, R. Glendenning of the Dominion Entomological Laboratory at Agassiz has conducted studies of the pea moth for a number of years in this region. He records the present known range of the insect as being the "Lower Fraser Valley from Hope at the foot of the Cascade Mountains west to the sea, and on Vancouver Island." (It is also common in the State of Washington to the south adjoining this territory. Hanson and Webster (34) state that "The pea moth in Washington first became a pest of economic importance in 1928 in the Nooksack Valley, Whatcom County, approximately 12 miles south of the British Columbia line. The insect became a problem in the Skagit flats of the Mount Vernon district in 1933, although it undoubtedly had been present there some years before. Experienced seedsmen have reported observing injured peas as early as 1926.")

The pea moth was found near Courtney in 1933 by McDunnough, and Twinn in his annual summaries of "Insects of the Season" records it from Sumas in 1934 and from Agassiz district in 1934, 1935, and 1936. In his report for 1941 Glendenning records the pea moth from Lulu Island, from Point Grey, Vancouver, and from Saanichton on Vancouver Island. There is no record of this insect from the interior of the province.

Summary

The earliest records of the pea moth, *Laspeyresia nigricana* (Steph.), in Canada indicate that it was probably already rather widely distributed in the Eastern Provinces at the time these first observations were made. However, from the information available it is now considered very likely that this insect has been present in this country for at least the past 100 years. The present available records of its distribution in Canada are given and these cover all provinces, with the exception of Saskatchewan. Where the insect has become well established its abundance and the degree of injury it causes may fluctuate greatly over a period of years. The spread of the pea moth may possibly have progressed from east to west, where it appears to have followed a path on both sides of the International Boundary between Canada and the United States. The pattern of distribution and regional prevalence of the pea moth on the Gaspe Coast are given.

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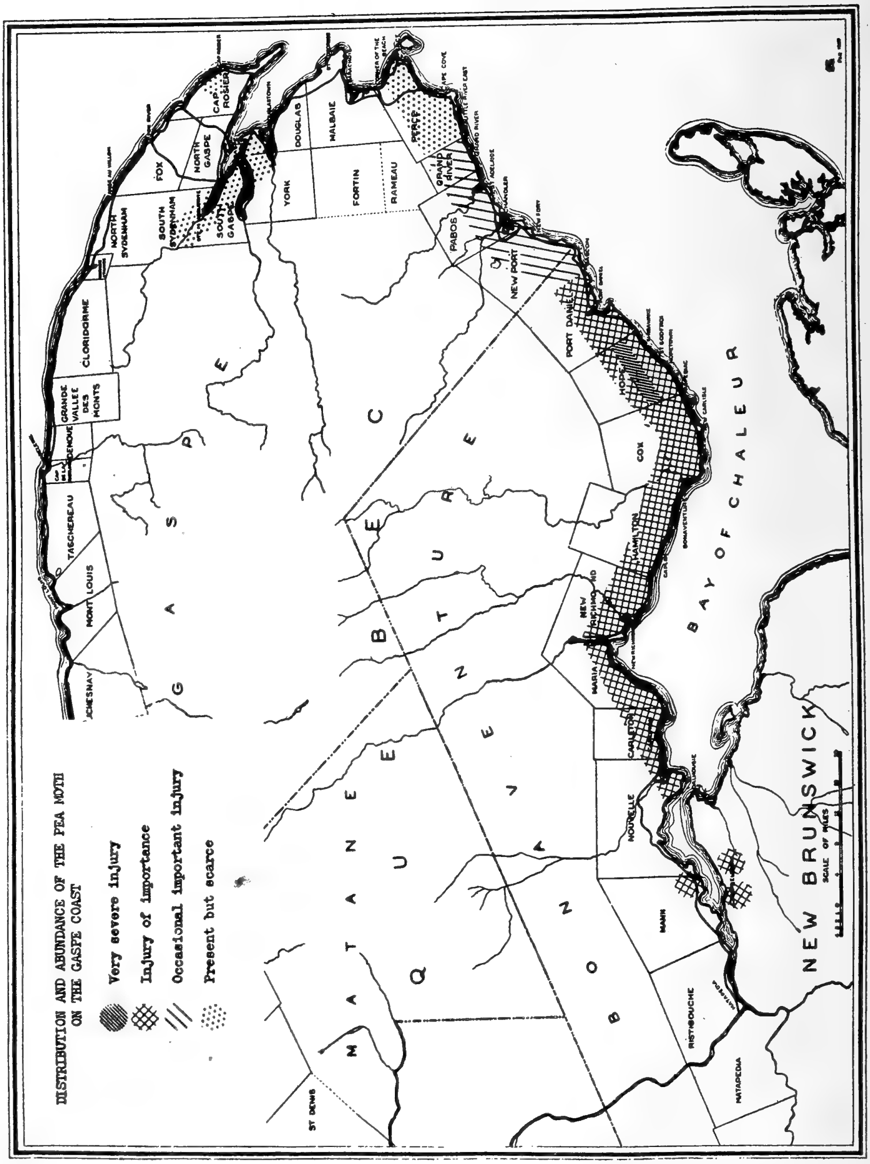

FIG. 1. Distribution and abundance of the pea moth on the Gaspe coast, 1936-1941

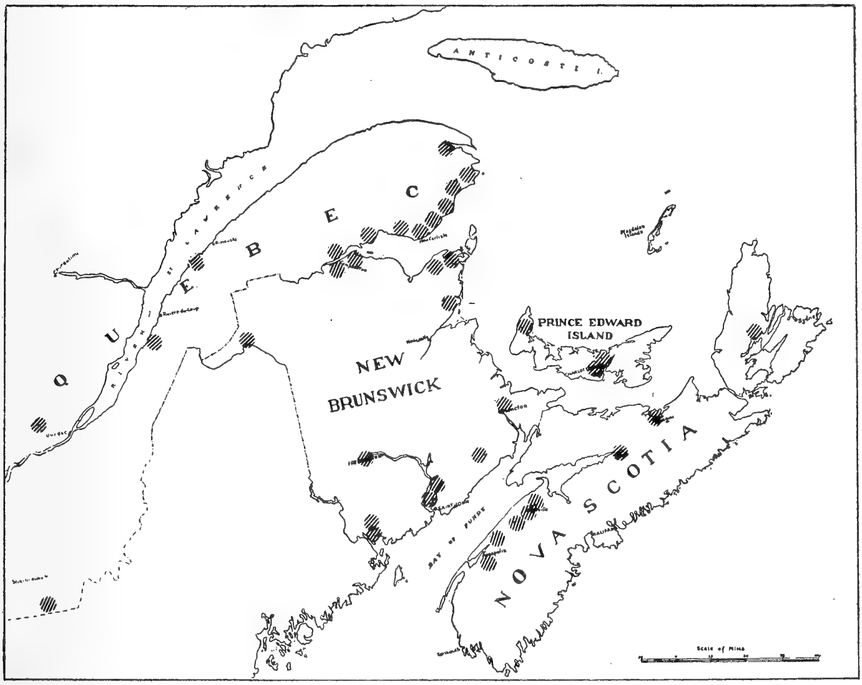

FIG. 2. Distribution recards of the pea moth in the Maritime Provinces and in eastern Quebec.

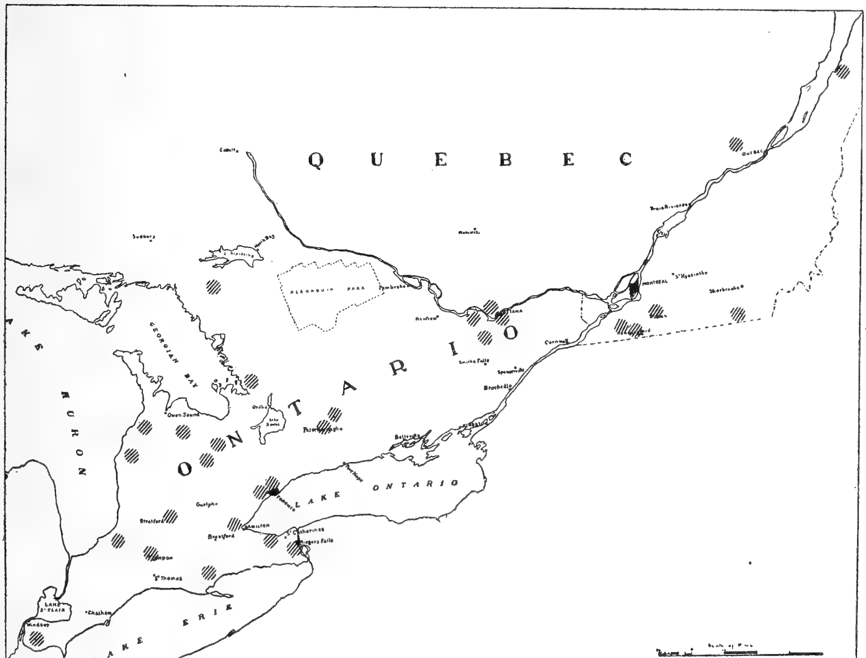

FIG. 3 Distribution records of the pea moth in the Province of Ontario and western Quebec.

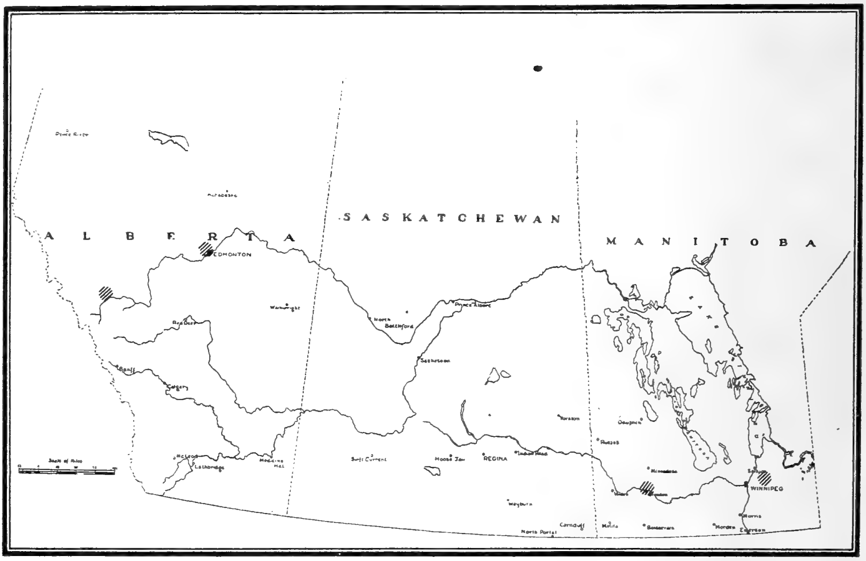

FIG. 4 Distribution records of the pea moth in the Prairie Provinces.

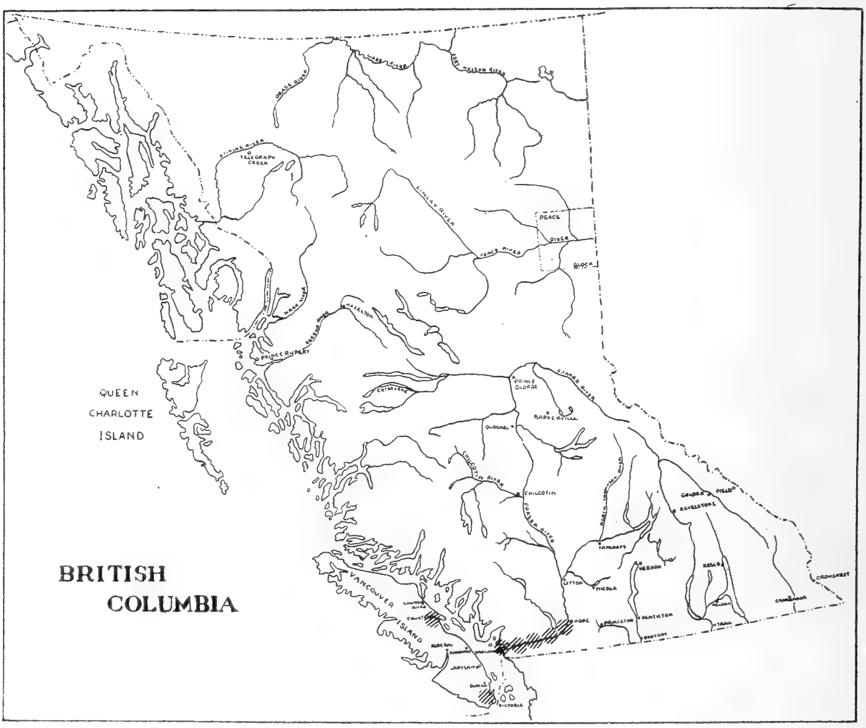

FIG. 5. Distribution records of the pea moth in the province of British Columbia.

MOLASSES-FREE BAIT FOR EARWIGS

By A. G. McNally

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During the summers 1942, 1943, series of tests were run in an attempt to obtain a suitable molasses-free bait for the European earwig (*Forficula auricularia*). The experiments were carried on in the Village of Ayton, Ontario.

In each test the bait was scattered over a modified Riley cage containing 25 earwigs and counts made approximately 7 days later. The cages were sealed with gummed paper and adhesive tape but, in spite of these precautions, almost invariably a percentage of the earwigs escaped. After heavy rains the percentage escaping was high. In computing the results every test in which more than 3 earwigs (12 per cent.) escaped was disregarded.

Tests indicated that the earwigs would not remain in the cages unless some cover was placed on the floor of the cage. In 1942 earth and sod were used but in 1943 it was found that a light sprinkling of earth covered with sheets of paper suited the insects and simplified the task of counting. It was later found that the earwigs could be kept satisfactorily in large glass jars and these will be used in any further work.

The following baits were tested:

1. *Oregon Formula*

Sodium fluoride	½ oz. (12 oz.)
Bran	½ lb. (12 lb.)
Molasses	2 2/3 oz. (2 qt.)
Water	8 oz. (6 qt.)

This formula has been used successfully as a bait in this area. It was used as a standard.

2. *Oregon formula less molasses*
3. *Bran, molasses, white arsenic and water*
   Same proportions as Oregon formula.
4. *Bran, white arsenic and water*
5. *Wheat distiller's grain, arsenic and water*
6. *Wheat distiller's grain, sodium fluoride and water.*

1942

	Cage 1		*Cage 2*		*Total*		
August 13	*Living*	*Dead*	*Living*	*Dead*	*Living*	*Dead*	*% Killed*
1. Oregon formula	10	13	8	15	18	28	60.87%
2. Oregon formula less molasses	6	10	9	13	15	23	59.09%
3. Bran, molasses, white arsenic, water	17	6	19	6	36	12	25.00%
4. Bran, white arsenic, water	21	0	19	3	40	3	6.98%
5. Check (bran + water)	25	0	19	0			0.00%
August 20							
1. Wheat distiller's grain and arsenic	20	2			20	2	9.09%
2. Wheat distiller's grain and sodium fluoride	22	1	20	2	42	3	6.66%
3. Oregon formula	8	15			8	15	65.22%
4. Oregon formula less molasses	8	17			8	17	68,00%
5. Check	20	0	19	0			0.00%

Heavy rains August 21, 27.

August 2δ	*Cage 1* Liv.	Dead	*Cage 2* Liv.	Dead	*Cage 3* Liv.	Dead	*Cage 4* Liv.	Dead	*Total* Liv.	Dead	*% Killed*
1. Oregon formula	18	5	16	8	16	7			50	20	28.28%
2. Oregon formula less molasses	15	5	17	6	16	6	15	8	65	25	27.77%

1943

July 20	*Cage 1* Living	Dead	*Cage 2* Living	Dead	*Cage 3* Living	Dead	*Total* Living	Dead	*% Killed*
1. Oregon formula*	4	2	2	7	3	18	Results not		
2. Oregon formula less molasses	2	12	3	15	10	12	computed. % recovery		
3. Check	13	0					too low.		
July 27									
1. Oregon formula	12	10a	9	14a	5	20b	26	44	63.89%
2. Oregon formula less molasses	9	13			12	11	21	24	55.53%
3. Check	23	0							
August 5									
1. Oregon formula	10	12	8	14	8	17	26	43	62.33%
2. Oregon formula less molasses	8	15	9	14	10	12	27	41	60.29%
August 13									
1. Oregon formula	8	6	5	7	7	14	Not computed. Less		
2. Oregon formula less molasses	7	6	6	12	10	5	than 88% of insects accounted for.		

*Rain soaked. Probably more dead in mud.
a. Bran mouldy from rain.
b. Bran with little mould.

Results:

After initial tests all baits but 1 and 2 were discarded.

In 15 counted tests Oregon baits averaged 56.11 per cent. kill.

In 14 counted tests Oregon bait less molasses averaged 54.10 per cent. kill. The molasses-free bait compares favourably in small scale tests. Probably tests would be necessary to indicate the relative merits in larger scale baiting.

SOME EXPERIMENTS WITH THE PYRETHRUM AEROSOL UNDER CANADIAN CONDITIONS[1]

By H. A. U. Monro[2], L. J. Briand[3], R. Delisle[4], *and* C. C. Smith[5].

The use of a highly volatile solvent such as dichlorodifluoromethane for the dispersion of insecticides in the form of aerosols has been described by Goodhue and Sullivan (1). The use of a pyrethrum aerosol against stored product pests was reported by Monro (2), who concluded that, under conditions requiring penetration into small cracks and crevices, the use of this aerosol would not be commercially practicable.

[1] Contribution No. 37, Division of Plant Protection, and Contribution No. 2285, Division of Entomology, Department of Agriculture, Ottawa, Ontario.
[2] Division of Plant Protection, Montreal, P.Q.
[3] Division of Entomology, Belleville, Ont.
[4] Division of Plant Protection, Montreal, P.Q.
[5] Division of Entomology, Fredericton, N.B.

During 1943 the divisions of Entomology and Plant Protection co-operated in a number of tests designed to explore the possible applications of this new technique under Canadian conditions.

In the majority of the experiments described in this paper, the aerosol was dispersed from a five pound storage cylinder through a steel capillary tube five inches long, with internal diameter of 0.017 inches, mounted with solder on the oil burner nozzles previously used. The oil burner nozzles were only used as a convenient aid to holding the capillary tube, although the wire filter screen in the nozzle was found to be of value for preventing the clogging of the tube by some of the waxy substances present in the pyrethrum extract. Some tests were also made by mounting hypodermic needles of various internal diameters and lengths directly onto the cylinders. This latter method appeared to give very satisfactory aerosols, but no accurate tests have yet been made to determine the most suitable internal diameter or length for these needles. McGovran et al. (3) made preliminary observations on the difference in effectiveness of oil burner nozzles of 0.01 inch bore and capillary tubes 2 inches long of internal diameter of 0.030 and 0.017 inches, finding no significant difference in the mortality of houseflies of a pyrethrum aerosol dispersed through the two capillary tubes, but observing that the tubes were almost twice as effective as the burner.

In all the work described in this paper the standard pyrethrum aerosol was employed, consisting of 5 per cent. pyrethrum extract 20 per cent. (containing 1 per cent. pyrethrins) 2 per cent oil of sesame and 93 per cent. dichlorodifluoromethane.

Tests Against Various Species of Insects

1. *Mushroom flies*:—In collaboration with Mr. J. B. Maltais of the Division of Entomology, St. Jean, P.Q., tests were carried out in mushroom houses against mushroom flies (*Sciara* sp.) using, in this case, the oil burner nozzle. The houses each had a capacity of 24,000 cubic feet, including the space occupied by the beds, and temperatures ranged from 52-55 degrees F. The ventilators were closed and after application of the aerosol the houses remained sealed for two hours, the maximum period without ventilation permitted by principles of good mushroom culture.

It was found that commercial control comparable to that obtained by routine application of a pyrethrum dust could be effected by ½ ounce of the aerosol per 1,000 cubic feet. There was no odour after two hours and the mushrooms were not affected. The standard dust used in these houses contains 0.35 per cent pyrethrins and is applied at the rate of 2 pounds per house every other day, each treatment costing 70 cents for material. The cost of the aerosol under Canadian conditions at the time of treatment was approximately $1.25, using 12 ounces to the house. The use of the capillary tube and other refinements could conceivably enable this aerosol to be used on a commercial basis, especially in view of its ease of application and even dispersion.

2. *Blackflies and other Diptera*:—Tests were conducted against blackflies in the Provinces of New Brunswick and Quebec.

At the Acadia Forest Experiment Station, Fredericton, N.B., it was found that when the weather was fair and warm, blackflies readily entered a sail silk tent of 700 cubic feet capacity. At temperatures of 75 degrees F., using the capillary tube, 1/20 ounce per 1,000 cubic feet caused only 50 per cent. of the flies to drop, all the fallen flies dying within 8 hours. With 1/10 - 1/11 ounces all the flies dropped in 1 to 3 minutes, and all succumbed within 8 hours. At lower temperatures round 60 degrees F. higher doses up to ¼ ounce per 1,000 cubic feet were required.

At the Parke Reserve Entomological Laboratory, Saint-Alexandre, P.Q., a special outdoor chamber was constructed of board covered with tar paper, with a capacity of 100 cubic feet. This chamber had glass windows for observing the flies, and a door for introducing the insects, fitted with a special orifice through which to inject the aerosol. Flies were collected in the field with a net and brought to the chamber in a

screened cage. After introduction into the chamber they were allowed a few minutes to settle and the aerosol was then introduced. The falling flies were allowed to drop into cardboard trays placed on the floor of the chamber, from which place they were readily collected for observation.

It was found that the aerosol applied at the rate of approximately 1/10 ounce per thousand cubic feet for a period of one hour was completely toxic to all the flies tested, at temperatures of 70 to 80 degrees F. The flies tested were grouped in families as follows:

SIMULIIDAE
Prosimulium hirtipes Fries
Simulium venustum Say

TABANIDAE
Chrysops mitis O.S.
Chrysops carbonaria Wlk.
Chrysops excitans Wlk.
Tabanus affinis Kby.

MUSCIDAE
Pyrellia serena Mg.

SARCOPHAGIDAE
Sarcophaga aldrichi Park

CALLIPHORIDAE
Phormia regina Mg.
Protophormia terrae novae R.D.

It is interesting to note that observations through the windows showed that the blackflies (Simuliidae) dropped almost immediately after dispersion of the aerosol, followed rapidly by *Tabanus affinis* Kby. a large sized horsefly, while the deerflies (*Chrysops* sp.) fell several minutes later. The other flies (Calliphoridae, Muscidae and Sarcophagidae) stayed much longer, some individuals falling after 10 to 15 minutes. The chamber used, while excellent in other ways for these tests, was too small to allow accurate measurement of the dosage, thus precluding comparative tests at different doses.

From these preliminary tests it is clear that some species of blackflies are quite susceptible to the pyrethrum aerosol at doses approximating those recommended for mosquitoes, 1/10 to 1/15 ounces per thousand cubic feet.

3. *Cockroaches*:—The use of aerosols against the German Cockroach *Blatella germanica* L. suffers to a large degree from the same disadvantages as the employment of sprays. Many roaches are driven away by the stimulating action of the pyrethrum, while the egg capsules are not reached in the cracks and crevices where they are lodged. In fact, in tests with the aerosol, normal numbers of nymphs subsequently hatched from egg capsules dropped by the females and fully exposed to the mist. It appears, therefore, that the aerosol, while bringing out into view spectacular numbers of cockroaches in badly infested structures, is not an answer to the problem under most conditions. It might be employed as a diagnostic agent for testing the effectiveness of other methods of control, in view of the rapid and unfailing response of a population of cockroaches to the stimulus of its vapours.

In one specialized environment, however, the aerosol was found to be of some value. In railroad dining cars railway officials are reluctant to recommend the use of powders, having in mind the possibility of accidents as a result, firstly, of the cramped space in the kitchen and pantry and, secondly, of the human factor prevailing during the rapid serving of meals in transit. At temperatures above 60 degrees F. it was found, in a number of tests, that the active population of *Blatella germanica* L. could be reduced by 90 to 95 per cent. by one application of the aerosol, applied at the rate of 2 ounces per 1,000 cubic feet using the capillary tube. In the first application the whole car was treated after the kitchen and pantry had been done in order to catch escaping cockroaches, or those free in the body of the car.

As many as seven applications were made in each car at intervals of 1 to 4 weeks. In subsequent treatments a further decline in the population was noted until was reached what appeared to be an irreducible level of population of a few nymphs and

adults. This level may have been partly maintained by reinfestation during the daily stocking of the pantry. After the first exposure it was found unnecessary to treat the main body of the car, and the kitchen and pantry section was sealed off for the subsequent treatments.

This aerosol, if applied at regular intervals by a member of the crew, could maintain the cockroach population at an insignificant minimum without danger to human beings. It may be mentioned, however, that at the dosage employed it was found advisable to wear a small antidust type respirator, equipped with a filter recommended for use against particulate suspensions, in order to avoid an unpleasant irritation of the membranes of the mouth, nose and throat.

4. *Sawfly larvae*:—Larvae of the mountain ash sawfly *Pristiphora geniculata* Htg. were found to be very susceptible to small amounts of the aerosol. In one test at Saint Alexandre, P.Q., 2/3 ounce of the aerosol (cost about 6 cents) projected into an uncovered 15 foot mountain ash tree in 40 seconds in still air caused all the population of larvae to fall in a short time, and subsequently die. This treatment caused no damage to the foliage and there was, of course, only a minute amount of pyrethrum deposited on the leaves. It is thought that population studies could be made in this manner. Sawfly and lepidopterous larvae are readily shaken from trees, but moths, leafhoppers and other active stages of insects might be collected in this way with or without the aid of covers for the trees.

Acknowledgments:—The authors wish to acknowledge the assistance given by Mr. A. B. Baird of the Belleville Laboratory, Division of Entomology, and his staff, in designing and fitting out the various types of nozzles used in these tests. Valuable assistance in arranging for and helping carrying out the tests was also given by the following: Dr. R. G. Law, Chief Sanitary Officer, Canadian National Railways; Mr. R. E. Balch, in charge of the Dominion Entomological Laboratory, Fredericton, N.B., and Mr. J. B. Maltais in charge of the Dominion Entomological Laboratory, St. Jean, P.Q.

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PEAR PSYLLA CONTROL IN BRITISH COLUMBIA AS AN INTERNATIONAL PROJECT*

By W. N. KEENAN

Plant Protection Division, Department of Agriculture, Ottawa

The pear psylla (*Psylla pyricola* Foerst), which has been present in eastern North America for many years, was found near Spokane, Washington, in 1939, which was the first record of this pest on the Pacific coast. A survey to determine distribution was started immediately by the United States Department of Agriculture and since that time the insect has been found throughout a large area in the State of Washington as well as in Idaho and Oregon. The Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, in co-operation with the States concerned, organized an intensive control and eradication program involving the application of several sprays to all pear and quince trees in the infested areas during each season as well as to trees in a protective zone around each area, and the removal or killing of neglected trees and living stumps.

*Contribution No. 36—from the Plant Protection Division, Department of Agriculture, Ottawa.

With the discovery of this pest near the Canadian border, offiicials in charge of the control work were anxious to determine whether the pest had become established in British Columbia and thus affect their control program. Accordingly, arrangements were made to assign a number of their experienced scouts to assist members of the Dominion and British Columbia Departments of Agriculture in carrying out a survey of the southern Okanagan Valley in 1940. Similar arrangements were made in 1941 but no signs of the pest were noted during either year. In 1942, however, this co-operative scouting resulted in finding the psylla near Oliver in early July and as scouting progressed, it was ascertained that the insect was present in a large number of orchards as far north as Penticton and also at Keremeos.

As a result of a conference held in Washington in late 1942, which was attended by the Dominion Entomologist, the Bureau of Entomology and Plant Quarantine decided, with the approval of the Dominion and British Columbia Departments of Agriculture, to extend control activities to the infested areas of British Columbia and by the spring of 1943 all necessary arrangements were made for this activity including the co-operation of the Canadian Immigration and Customs regarding the entry of United States officials, crews and equipment and with the oil controller for Canada concerning gasoline and oil supplies. An officer of the Plant Protection Division was transferred from eastern Canada to act as collaborator in the field on behalf of the Dominion Department of Agriculture. Local representatives of the Provincial Department of Entomology, took an active part in the organization and spraying operations and in facilitating the work.

During the season three sprays were applied in all pear orchards in the Okanagan Valley as far north as Oliver as well as at Okanagan Falls, Koleden and Penticton, including additional orchards found infested in the area during 1943 scouting operations. In the first two sprays, summer oil emulsion and nicotine sulphate in the proportion of 1 gallon of emulsion to ¾ pint nicotine sulphate per 100 gallons of water was applied. In the final spray, fish oil was used as a substitute for oil emulsion at the rate of 1 quart per 100 gallons water. Throughout the spraying season, 62,055 gallons of spray material were used in this control work in the southern Okanagan Valley which required 9,709 man hours to apply.

All reports indicate that full co-operation prevailed throughout the work. The fruit growers throughout the area and other property owners were very considerate and helpful and all have spoken highly of the care and efficiency with which the United States officers in charge and workers carried out the program.

THE INFLUENCE OF FERTILITY ON THE FEEDING RATE OF THE FEMALE OF THE WOOD TICK, *DERMACENTOR ANDERSONI* STILES*

By J. D. Gregson

Livestock Insect Laboratory, Kamloops, B.C.

Tick paralysis, in its American form, is a condition produced in livestock and man through the feeding on them of one or more female wood ticks of the species *Dermacentor andersoni* Stiles. The disease, often fatal if the tick is not removed in time, does not become apparent until the tick is close to being fully replete, which state does not occur until at least seven days after the tick's attachment. It is, however, almost invariably the rule that the causative parasite is a fast feeder. That is to say, the tick concerned will have been replete by the seventh day from its attachment to its host, at which time paralysis will most likely have been present during the last twelve or more hours. Rarely does a female feed faster than this; more often they may take up to two weeks to engorge. Ticks which take over seven days seldom

*Contribution No. 2278, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

afflict their hosts with the symptoms of paralysis, even when a group of them are engorging simultaneously. Since little is known concerning the true nature and cause of this disease, anything pertaining to the feeding of the female tick is of extreme interest, and many experiments have been conducted by officers of the Dominion Livestock Insect Laboratory at Kamloops in an attempt to explain why some ticks feed more rapidly than others.

From experiments in this line, it has been found that ticks feed very reluctantly towards the approach of autumn, and that fluctuations in temperature and exposure to ultra-violet light increase their appetites. Smith and Cole (1941) have also discovered that the feeding activities of early stages of ticks are influenced by the length and variety of photoperiods to which they have been subjected. Recently it was found that under certain (unknown) conditions the presence of male ticks will stimulate the feeding rate of the females. Since this species of tick copulates while engorging, it is presumed that the feeding rate may be associated with this behaviour. In any case, in this particular instance, and in one previous infestation, the results of the experiment were so marked as to warrant this note. Four series of *D. andersoni* ticks were encapsuled on a sheep on October 1st. With two groups of four and five females (numbers 1 and 3) were included an equal number of males. The other two groups of six and seven ticks (numbers 2 and 4) consisted of females only. At the end of a week the capsules were removed. The sheep was then showing signs of paralysis and all of the paired females had become engorged and detached. The unmated ticks, on the other hand, were still all attached and only about half engorged.

The results of this experiment appear to point conclusively towards the fact that the presence of males stimulates the feeding rate of the females. However, as has been the case in so many tick paralysis observations, there is evidence of a conflicting nature. This is seen in the results of some large scale infestations made in April, 1940, when a *pair* of ticks was placed on each of fifty day-old lambs. In this instance not one of the females fed rapidly.

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Further references pertaining to tick paralysis may be found in the paper:

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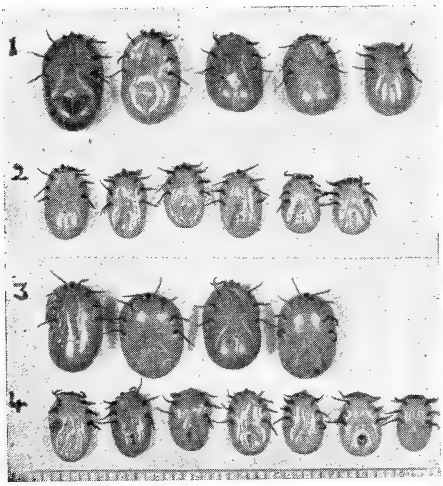

Showing the difference in feeding rate between mated (Figs. 1 and 3) and unmated (Figs. 2 and 4) Wood ticks. Natural size.

A NEW PEST ON BLACK WILLOW IN QUEBEC

By Joseph Duncan

Quebec Plant Protection Division, Montreal

This small chrysomelid beetle, *Gastroidea syanea* Melsh, which was first callected in Quebec by Mr. Lecavalier and identified by Brother Ouellette, originated in Southern Indiana, occurring on various species of dock (*Rumex*) from the middle of April to mid-June.

The length of this insect is 4–5 mm., oblong—oval; uniformly brilliant, green or blue; antennae, legs and under surface of the body purplish black; head and throax finely and sparsely punctate, elytra densely and rather roughly punctate. Tibiae grooved on outer side, tarsi bilobed on the third joint.

In the Oka district, the native black willow, *Salix nigra,* was greatly affected by this insect in 1943. This beetle appears to be very prolific. Some of the ornamental black willows were defoliated by both larvae and adults. The chlorophyll tissues are skeletonized by the larvae, while the adults cut the leaves along the edge, making more apparent damage.

Ornamental trees were treated with pyrethrum and derris powder (4 per cent. rotenone). Derris gave a fair measure of control compared with pyrethrum.

THE ESTABLISHMENT OF SOME IMPORTED PARASITES OF THE LARCH CASEBEARER, *HAPLOPTILIA LARICELLA* HBN., IN ONTARIO*

By A. R. Graham

Dominion Parasite Laboratory, Belleville, Ontario

The larch casebearer, *Haploptilia laricella* Hbn., is a single-brooded, microlepidopterous pest of the larch or tamarack, *Larix* spp., in Canada. It is thought to be of European origin, the first record of its being found on this continent coming from Massachusetts in 1886.

Life History in Belleville District

The tiny grey moths begin emerging during the last week in May and continue until the end of June. Oviposition occurs from the first of June until almost the middle of July. Egg hatching may be prolonged until the end of the first week or ten days of August, as much as a month having been noted to pass before eggs under observation hatched. In the process of hatching, the young larva cuts its way through the egg-shell into the leaf to which the egg is attached, without exposure to the outer air. This is possible since the egg is hemispherical in shape, the flat side being attached to the needle. The young larva mines in the needle during August, after which it cuts off the required amount of hollow needle to make its case and, transporting the case on its abdomen, moves on to mine other needles. It carries this case throughout its larval stages, increasing the size of it when necessary by inserting silk in an opening along one side, or even abandoning its hibernation case for a larger one the following spring. Most of the feeding larvae have supplied themselves with cases by the end of September. Feeding may continue until the end of October, hibernation not being

*Contribution No. 2282, Division of Entomology, Science Service, Department of Agriculture. Ottawa, Canada.

completed until November 10th in some cases noted. For hibernation the case is tied by silk threads to the bark of the outer twigs. Several cases are usually found grouped around the base of the spurs from which the needles arise the following spring. The larvae become active in spring as soon as the needles of the host tree are one-eighth to one-quarter inches long, usually in the last week in April. Feeding continues until the end of May. Pupation begins about the tenth of May and the pupal stage lasts for two weeks. During pupation the cases are tied to the needles in the centre of the fascicle of needles and not to the bark as in hibernation. The cases may also be tied to lichens on the bark of the larger branches.

Injury

The greatest amount of damage to the trees results from the spring feeding when the larvae are becoming full-grown and eating a great deal, and the trees are in their period of greatest growth, less damage results from the first larval feeding in August, September and October when the larvae are very small and most tree-growth has ceased, and the trees are hardening off for the approaching winter.

Reproduction Potential of the Casebearer

The larch casebearer has enormous potentialities for increasing its numbers on a tree. During the winter of 1933-4, the large overwintering population in the Belleville district was almost completely destroyed by low temperatures, yet the population that went into hibernation in the fall of 1934 was seven-fold that of the fall of 1933. In 1943 the heaviest population yet recorded is going into hibernation at Melrose where a larch plot has been under observation since 1931, yet the casebearer population in that plot has been down to a minimum during the last seven or eight years.

Native Parasitism

A large number of species of native parasites have been found attacking *H. laricella* but they have not occurred in sufficient numbers to be considered of value in controlling this insect. Species reared usually occur in certain localities, all or several species never occurring in every locality. For instance, a *Microbracon* species occurred in the Ottawa and Millbridge districts but not in the Melrose plot or the St. Williams Forestry Station, and similarly, a chalcid, *Spilochalcis* sp. occurred only at Millbridge and only for one season.

Following is a list of native parasite species which have been reared from *H. laricella* Hbn. since work was started with this insect at Belleville in 1931. *Gelis* sp., *Itoplectis* sp., *Lissonota parva* Cress., *Syrphoctonus agilis* Cress., *Hemiteles tenellus* Say., *Phaeogenes* sp. near *epinotiae* Cush., *Inareolata* sp., *Exochus* sp., *Angitia* sp., *Microbracon pygmaeus* Prov., *Clinocentrus* sp., *Hormius* sp., *Bracon* sp., *Euderus amphis* Walk., *Habrocytus phycides* Ashm., *Spilochalcis albifrons* Walsh., *S. zanthostigmata* Dlm., *Calliceras sp.*, *Euplectrus millipes* Prov., *Pachyneuron altiscutum* How., *Tetrasticus* sp., *Achrysocharis* sp., *Phanurus ovivorus* Ashm., *Trissolcus euschisti* Ash., *Polynema* sp.

Parasite Introductions

Previous to 1931 the Dominion Entomologist arranged with the Imperial Parasite Service to study the possibilities of securing parasites of the larch casebearer in England for shipment to Canada. Under the direction of Dr. W. R. Thompson, Dr. Thorpe undertook the project in England and the first consignment of parasites arrived in Canada in 1931, followed by much larger shipments in 1934, 1935, 1937, 1938 and 1939. Some material was secured from Northern Bohemia, Czechoslovakia in 1938.

When the first shipment arrived in Belleville the parasites were emerging and the weather was extremely hot. We were also without the services of our present air conditioner quarters, and under the existing conditions emergence was very poor—

only 20 *Angitia nana* being secured for liberation. These were liberated in a small larch swamp at Holloway, eleven miles north of Belleville, which had shown a high infestation of casebearer the previous spring. Moths were still flying, and only a few eggs were hatched at the time of parasite release. This fact, together with the poor condition of the parasites, precluded the possibility of their establishment and no recoveries have been made to date as a result of that liberation.

In subsequent introductions, the material was collected a little earlier in England and shipped to us in the vegetable chill room of the steamer, with the result that it was possible to place the material in cold storage upon its arrival in Belleville, and keep it there for a considerable time with very little mortality.

The following table shows the number of larch casebearer cases imported with the latest daté of arrival of shipments at Belleville each year. Also shown are the number of days in storage here and the date the material was put out for emergence of the contained parasites.

TABLE I

Year	*No. cases*	*Last date*	*Days stored*	*Date taken out*
1934	64,757	July 7	11	July 18
1935	118,344	June 29	22	July 21
1937	80,000	June 14	35	July 19
1938	59,900	June 5	53	July 28
1939	75,000	June 8	34	July 12

Method of Handling Parasite Material

Several methods were used in handling the material when it was put out for emergence. The best method used was to place the cases in a shallow wooden tray with a glass top, the bottom of which was covered with blotting paper. Several trays were stacked, one on top of the other, to exclude light, and emergence was taken in one-inch vials placed in holes along one side of the tray. The cases were spread out loosely on the blotting paper and were moistened daily after emergence was taken. The parasites were inspected individually under a binocular microscope to determine their species and eliminate undesirables and were then placed in cool storage at 40° – 44° F., until a sufficient number had emerged for a liberation shipment.

Species of Parasites Secured

Five species of parasites were secured and liberated by the end of the 1937 liberation season. These were *Angitia nana* Grav., *Microdus pumilus* Ratz., *Dicladocerus westwoodi* Steph., *Chrysocharis laricinellae* Rtz., and *Cirrospilus pictus* Nees.

Parasite Liberations from Imported Material

Liberations of parasites were made each year from the material imported. These liberations are tabulated as follows:

Parasite	1931	1934	1935	1937	1938	1939	Total
A. nana	20		42	35			97
M. pumilus				246	434	357	1037
C. laricinellae		3925			16950	8789	29664
D. westwoodi		44	881	916	335	1107	3283
C. pictus		108			235	163	506
Total	20	4077	923	1197	17954	10416	34587

All liberations in 1934, 1935 and 1937 were made at Millbridge, Ontario, 44 miles north of Belleville, in a forest which extends northward into Algonquin Park and contains a considerable percentage of larch. In 1934 and ever since, this forest area has sustained a medium to heavy infestation of larch casebearer.

In 1938 *C. laricinellae* and *D. westwoodi* were liberated at Kemptville, Ont., and *C. laricinellae, C. pictus* and *M. pumilus* at Ottawa.

In 1939 all imported material was liberated at the Ontario Forestry Branch, St. Williams, Ont.

Recoveries of Imported Parasites

The first recoveries of imported parasites were made at Millbridge in 1936 when *A. nana and D. westwoodi* were taken. In 1937 the same species were again taken at Millbridge, Ont.

In 1941 *M. pumilus* and *C. laricinellae* were recovered at Millbridge and *C. laricinellae* at Ottawa, Ont. In 1942 *M. pumilus, A. nana* and *C. laricinellae* were recovered at Millbridge, Ont., and in 1943 *M. pumilus, C. laricinellae* and *C. pictus* were recovered at Millbridge, Ont.

Parasite Recolonization

In 1942 *M. pumilus* and *C. laricinellae* were recovered in sufficient numbers from a small lot of material collected at Millbridge, Ont., to make small recolonization liberations at the Angus, Ontario Forestry Station and the Berthierville, Quebec Forestry Station.

In 1943, a much larger amount of material was brought from the Millbridge liberation point, from which 5323 *M. pumilus* and 8505 *C. laricinellae* were secured. These parasites were liberated at Angus, Ont., Berthierville, Que., and Fredericton and Saint John, N.B. The largest number was shipped to Fredericton, N.B.

General Notes on the Biology of These Parasites

Thorpe states that *A. nana* emerges in England during the first three weeks in June and females have been found alive there on August 28th still containing from 50 to 100 well developed eggs. This, and the fact that *A. nana* was the most abundant and widely distributed parasite obtained n England prior to 1931, led Thorpe to make the statement that this would be the best species to liberate in Canada. From our observations, *A. nana* might become established more readily in Canada if we could import it in numbers comparable to the numbers of the other species that we have liberated. However, the greater number of *M. pumilus* and *C. laricinellae* recovered at Millbridge in 1942 and 1943 would tend to indicate that the two latter species may be of more use in Canada.

With the exception of *C. pictus,* of which nothing of the biology is known, the other four imported species are internal larval parasites, hibernating in the host as first stage larvae.

From collections made at five to ten miles distant in several directions from the Millbridge liberation point we are led to believe that these parasites will spread quite slowly and, therefore, it would seem to be advisable to recolonize the parasites at frequent intervals in large areas of larch infested with the casebearer.

Summary

1. The larch casebearer, a pest of primary importance in Canada has been known on this continent since 1886.

2. It is a single brooded insect.

3. Its reproductive potential is very high.

4. Upwards of 25 native parasite species have been reared but never in sufficient numbers to indicate them as being of benefit in controlling the host.

5. Introductions of imported parasites have been made from Europe. Liberations have totalled 34,587 individuals belonging to five species.

6. Recoveries of all five species have been made at the initial liberation point, near Millbridge, Ont.

7. Recolonization of three of these species has been made at Ottawa, St. Williams and Angus, Ont., Berthierville, Que., and Fredericton and Saint John, N.B.

8. It is thought possible that *M. pumilus* and *C. laricinellae* will become better established and be of more use than the other species.

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THE STATUS OF THE SPRUCE BUDWORM IN ONTARIO AND WESTERN QUEBEC IN 1943*

By C. E. Atwood

This continues to be the most destructive forest insect in Western Canada. In 1943 the main outbreak enlarged considerably in area and new patches of heavy attack appeared around Lake Nipigon and in western Quebec. The main heavy outbreak now extends from the Coulonge River, a tributary of the Ottawa, to the White River, which drains into Lake Superior west of Michipicoten. In addition, a severe outbreak is present in the western part of Algonquin Park and the areas north and south of it and another occurs on the west, south, and east of Lake Nipigon. Smaller and somewhat isolated infestations are found near Sioux Lookout and south of Lake Abitibi. Apparently all the forested area of Ontario in which balsam fir is found supports a light infestation which can be detected by careful examination. The eastern limit of this light infestation is not known but it lies east of the Gatineau Valley. Reports indicate that adults were found in the city of Montreal in 1943.

While the outbreak has on the whole continued to spread, a number of small isolated infestations have practically died out without causing much tree mortality. Infestations of this type were noted in 1939-1941 at the following places, and doubtless were present at other points not recorded: near Kingston; Almonte; near Pembroke; Port Alexander; Rutherglen; Redbridge; Round Lake, near Sudbury; Thessalon-Bruce Mines; Searchmont; near Cochrane; many points along North Bay to Huntsville highway, along Sault Ste. Marie to Montreal River highway, and along Algoma Central Railway between Searchmont and Agawa.

The total area within which balsam appears to have suffered such heavy mortality that salvage is no longer possible appears to be about 12,000–15,000 square miles. Within this type of country the spruce budworm is now at a very low ebb because of the scarcity of food. Surrounding these patches of dead and dying balsam are much more extensive areas, totalling probably an additional 30,000 square miles,

*Contribution No. 2293, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Ont.

where the balsam has lost most or all of its new foliage and some old for the last two to four years; single trees and small patches of trees are dead and many others are in bad shape but no really extensive killing has occurred. Little real damage has yet been caused in the lightly infested areas.

The total amount of balsam killed is difficult to estimate from the data available but it seems probable that at least one-half of the 25,000,000 cords present in Ontario forests in 1931 are now dead or injured beyond recovery. The amount of white spruce killed probably runs into millions of cords; more exact figures are impossible at present. This cannot be considered as an absolute total loss, since much of the balsam was mature and inaccessible and would probably have died from old age before it could have been utilized even if it had not been killed by insects. Some white spruce was also of this type. On the other hand, many stands which could have been profitably logged a few years ago are now in such a condition that they must be considered inaccessible even though they still support fair quantities of white and black spruce. The balsam and some white spruce have been killed and have in some cases blown down, thus reducing the cordage per acre and at the same time adding to the difficulties of logging; further blow-down has occurred and will occur among white and black spruce, jack pine, poplar and white birch where they occurred in mixtures with balsam. The result is a forest in which it is almost impossible to salvage even the black spruce unless the latter occurs in large pure blocks.

Two other bad results of budworm attack are the increased fire hazard and the change in forest composition effected by wholesale destruction of balsam. For about ten years after the peak of a budworm outbreak, fire hazard in the devastated areas is extremely high. While it is possible that a fire under proper conditions may be the best treatment for an area in which a heavy stand of balsam has been killed ,the difficulty lies in restricting the fire to those portions of the forest which will benefit thereby. Under the usual conditions, once the fire starts, it may burn forest which has not been affected by budworm and is still valuable. And while there is some evidence that fires may at certain times produce a more desirable type of reproduction than that which comes in on undisturbed budworm areas, a summer fire through a dead balsam forest may be so hot that many sites will be rendered unfit for tree growth for time time.

Reproduction in budworm-killed forests usually consists of a very high proportion of balsam, often so dense that it may partially stagnate at an early age and fail to make proper growth. This simply sets the stage for another budworm outbreak within 50 years or so while at the same time producing only a meagre crop of pulpwood.

It is therefore very difficult to set a money value on the balsam and spruce which has been killed since even in inaccessible areas where the present stand is of no commercial value the ultimate effects may be extremely bad.

Egg counts at some ten representative points indicate that a heavy attack will occur again in 1944 unless some unexpected factor makes its appearance. A certain amount of spread may occur around the whole periphery of the outbreak but in general this is not likely to be extensive because of the absence of mature balsam stands which seem to be necessary for the support of destructive outbreaks. However, the eastward spread into Quebec may continue beyond the Gatineau valley. The percentage of balsam in the forests of Quebec is in general higher than is the case in Ontario. Part of this forest was devastated by former budworm outbreaks and in these areas little mature balsam is now present, but over a large portion of the province balsam forms a major part of the pulpwood stands. The danger of a destructive outbreak in this area is therefore present. The most interesting and important questions in Canadian forest entomology are: Will an outbreak take place in these areas and, if not, why not?

On the north, a certain amount of extension may take place in particular areas, especially along rivers where balsam occurs on the banks. Around Lake Nipigon, there are still extensive stands of balsam and white spruce only lightly infested and it seems probable that these will eventually be severely damaged. In the Kenora district also there are said to be considerable areas of balsam in which hevay attacks may develop in the near future.

The remaining portions of Ontario, including most of the Clay Belt and the black spruce country in general, appear to be safe from heavy attack.

A SUMMARY OF THE MORE IMPORTANT INSECT PESTS IN CANADA IN 1943*

By C. R. Twinn

*Division of Entomology, Ottawa***

Field Crops and Garden Insects

The wheat stem sawfly, *Cephus cinctus* Nort., was the most outstanding pest in Saskatchewan and Alberta in 1943, and caused very severe crop losses. General light crop stands greatly increased the losses by permitting sawfly-cut stems to fall to the ground, where most were lost in harvesting. Up to one-third of the heads were lost in this manner over a wide area of southwest Saskatchewan, and more than 50 per cent in many cases in southern Alberta. Crop losses throughout the two provinces ranged from 5–10 per cent in the more lightly infested districts to as high as 75 per cent in areas where the sawfly was most abundant. The insect is much less important as a pest in Manitoba, but a higher loss than for some years was reported in south-western districts.

A further material decline in grasshopper abundance and damage occurred in the Prairie Provinces, but there was an exceedingly heavy outbreak in British Columbia. In Manitoba, the grasshopper outbreak forecast in the northern Red River Valley, Manitoba, failed to materialize and very little damage was done, thanks to the late, wet spring. The unusually cold spring also greatly delayed hatching of grasshoppers in Saskatchewan and Alberta and the development of nymphs and adults was subsequently retarded, with the result that, except locally, loss to grain crops was slight to negligible. However, flax and late crops suffered some losses. There were no migrations of adults from United States territory in 1943 and none are anticipated in 1944. In British Columbia the worst outbreak of grasshoppers since 1921 developed. This was caused by a tremendous and widespread increase of the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* Saus.. Range areas all over the province, except in the Nicola Valley where efficient control had been maintained, were completely stripped. Damage was also done to almost all kinds of cultivated crops.

Blister beetles were much less in evidence in the Prairie Provinces than for some years past but, in British Columbia, associated with the grasshopper outbreak, they were extremely abundant throughout the southern interior, and damaged potato, tomato, and other field and garden crops. The most common and injurious species was *Epicauta oregona* Horn.

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*Contribution No. 2292, Division of Entomology, Science Service, Pepartment of Agriculture, Ottawa, Ont.

**Prepared from regional reports submitted by officers of the Division of Entomology and members of the Entomological Society of Ontario. The original reports may be consulted in the first issue of the 1944 volume of the Canadian Insect Pest Review.

Wireworms, chiefly *Ludius aereipennis destructor* Brown, caused average damage to the wheat crop in Saskatchewan, namely 5 to 6 per cent, as compared with approximately 4 per cent in 1942. Damage was greatest among crops planted on summerfallow in open prairie areas. Losses due to this species in Alberta were apparently less than usual. Damage to corn plantings was reported locally in Manitoba. Another species of wireworm was injurious to fields of tomatoes in Essex County, Ontario.

Cutworms of various species were generally average or below average in numbers and damage in Canada during 1943. The red-backed cutworm, *Euxoa ochrogaster* Gn., caused widespread losses in the areas of lighter soils of the wooded and park belts of Saskatchewan, west of a line from Prince Albert to Saskatoon. Grain, truck and garden crops were attacked. Some losses to beets and slight damage to peas and truck crops also occurred in irrigated sections of Alberta. The pale western cutworm, *Agrotis orthogonia* Morr., caused relatively little damage on the prairies in 1943. Slight to severe local outbreaks of the black army cutworm, *Actebia fennica* Tausch., occurred in Ontario, Saskatchewan, and British Columbia. This species is usually scarce and unimportant.

The usual infestations and damage by the Colorado potato beetle, *Leptinotarsa decemlineata* Say, occurred in Eastern Canada. The beetles were noted as late in appearing in New Brunswick, but the insect soon became abundant and, as control operations were interfered with by frequent rains, the larvae caused much damage. Less than usual trouble from the species was reported in Manitoba and Saskatchewan. In British Columbia, where the potato beetle has been confined to the extreme southeast corner of the province for many years, light infestations appeared far to the west, in the Okanagan Valley, from Ozoyoos to Okanagan Falls, where there are no natural barriers to prevent its spread into the potato-growing areas in the interior.

As usual, flea beetles were prevalent. The potato flea beetle, *Epitrix cucumeris* Harr., caused injury to potato and tomato plants in Eastern Canada and Manitoba. The larvae of an un-named species of *Epitrix* seriously damaged the main crop of potatoes in the Sumas, Chilliwack and Agassiz districts of British Columbia. The insect appears to be increasing and spreading westward. Species of *Phyllotreta* attacked crucifers in Manitoba and Saskatchewan. For the first time in Manitoba sugar beets were attacked by flea beetles. At Winnipeg, the red-headed flea beetle, *Systena frontalis* Fab., attacked potato plants. A heavy infestation of this species occurred on turnip in the Guelph district, Ontario. In northwest Saskatchewan the hop flea beetle, *Psylliodes punctulata* Melsh, was the principal species on crucifers. Several species of flea beetles were abundant on crucifers in Alberta and caused loss of early planted cabbage and radish locally in gardens.

Heavy injury by the potato leaf hopper, *Empoasca fabae* Harr., occurred in a considerable part of the potato growing area of Ontario in 1943, and hopper burn was prevalent. Light infestations of this species were reported in Prince Edward Island and Manitoba.

The potato aphids, *Myzus persicae* Sulz., *M. pseudosolani* Theo., *Aphis abbreviata* Patch and *Macrosiphum solanifolii* Ashm. were in reduced abundance in Prince Edward Island, New Brunswick and Quebec as compared with 1942. The two first-named species were reported attacking potatoes at Selkirk, Manitoba. The cabbage aphid, *Brevicoryne brassicae* L., was locally abundant in Ontario; attacked cabbage and brussels sprouts at Brandon and Treesbank, Manitoba, and was unusually abundant on cruciferous crops in British Columbia. Scattered infestations of the corn leaf aphid, *Aphis maidis* Fitch, were reported in New Brunswick, Ontario and Manitoba. Although widely present in the Dominion, no important outbreaks of the pea aphid *Macrosiphum pisi* Kltb., developed.

The potato psyllid, *Paratrioza cockerelli* Sulc., which was so abundant and caused such severe losses to potatoes for a few seasons in Alberta was practically non-existent in 1943. No reports of infestations were received in Saskatchewan.

The tomato hornworm, *Phlegethontius quinquemaculata* Haw., was injurious in tomato fields in Huntingdon and Chateauguay Counties, P.Q., and Kent County and elsewhere in Ontario. The infestation in the latter province decreased rapidly towards the end of August. Tobacco suffered little damage from this species.

White grubs caused widespread damage to crops in areas north and east of Montreal, but elsewhere were not generally important in 1943.

There was increased stalk infestation by the Europeon corn borer, *Pyrausta nubilalis Hbn.,* in southern Ontario and southern Quebec, compared with 1942, without apparent increased damage to the field corn crop. The infestation in the latter area was rather severe in early sweet corn, and light to moderate in canning corn. In Ontario, early table and early picked canning corn was heavily infested. For the first time in eleven years the corn borer (two larvae) was found in New Brunswick (in Fredericton).

Infestations of the corn earworm, *Heliothis armigera* Hbn., were heavy in Prince Edward Island and light in Nova Scotia and Ontario. The species was reported in corn and tomatoes at Swan River, Manitoba.

Root maggots, *Hylemyia* spp., caused injury to onions and cruciferous crops in varying degree, but in general there were no outbreaks of unusual intensity.

The beet webworm, *Loxostege sticticalis* L., was comparatively scarce in the Prairie Provinces and British Columbia in 1943. The sugar-beet root aphid, *Pemphigus betae* Doane, caused a serious reduction in tonnage and sugar content of sugar-beets from several fields in the Diamond City - Picture Butte area of Alberta. This is the first record of damage of this extent in southern Alberta.

The imported cabbage worm, *Pieris rapae* L., was, as usual, prevalent throughout the Dominion, causing damage of varying degree to cabbage and other crucifers, except in British Columbia, where it was reported to be remarkably scarce in 1943.

The sweet clover weevil, *Sitona cylindricollis* Fab., caused damage locally in Quebec and Ontario and generally in southern Manitoba. In the latter province some farmers are reported to be abandoning the growing of clover because of the annual losses. The species also caused severe damage in eastern Saskatchewan and noticeable but lesser damage elsewhere in the central and western part of its known range in that province. During 1943 it was also found to be fairly abundant east of Medicine Hat in Alberta.

The species, *Heliothis ononis* Schiff., referred to in reports as a "flax bollworm," and first recorded at Druid, Saskatchewan, in 1942, was widespread in flax fields in the west-central part of the province in 1943, eating the seeds out of the bolls and causing losses ranging up to about 12 per cent. It was also found in a field near Cereal, Alberta.

In 1943, the Mexican bean beetle, *Epilachna varivestis* Muls., was found for the first time in the Province of Quebec, in the counties of Chateauguay, Huntingdon, St. Johns, Stanstead and Brome. The beetle occurred over an area of several square miles in the vicinity of Franklin Centre. The northern limits of the infestation in southern Quebec were only a few miles from canning bean-growing areas. Scattered but locally severe infestations occurred in the Niagara Falls district of southern Ontario, and for the first time the species was found to be widespread in Prince Edward, Hastings, Lennox and Addington Counties north of the eastern end of Lake Ontario. No traces of the beetle were seen in New Brunswick, where it first appeared in 1942.

Fruit Insects

In the principal apple-growing sections of the Dominion, infestations of the codling moth, *Carpocapsa pomonella* L., were generally lighter in 1943 than in 1942, due to higher mortality of overwintering larvae, followed by seasonal conditions unfavourable to the species. In the Annapolis Valley, N.S., enough larvae entered winter quarters in the fall of 1942 to threaten a serious outbreak, but winter mortality and backward spring weather reduced the insects to average or below average proportions. In Prince Edward Island, counts made in several orchards showed less than one per cent of fruit infested, and in New Brunswick, the species was at a low ebb in the St. John River Valley area, and of little economic consequence. In Quebec, injury to apples was much less prevalent, perhaps one-half that of the previous year. In Ontario, the codling moth continued to be an outstanding orchard pest, but seasonal conditions were unfavourable to it, and control was effected more readily than usual. However, in the Niagara district, second brood worms were responsible for unduly high damage to apples, and caused more wormy pears than usual. In British Columbia, low winter temperatures in North Okanagan caused about 90 per cent mortality of over-wintering larvae above the snow level, and infestation of the 1943 crop was lower than for two seasons. In the South Okanagan, winter mortality was about 30 per cent and the resultant infestation was probably somewhat higher than in 1942. Throughout the Valley, cool, dry spring weather greatly protracted the emergence of moths from the overwintered larvae.

There was not much change in the infestation of the apple maggot, *Rhagoletis pomonella* Walsh, in commercial orchards in the Maritime Provinces and Quebec in 1943. In Ontario, however, a survey indicated a significant increase in the number of infested orchards and in the degree of infestation. Wet weather, which interfered with the effectiveness of spraying, and failure in some cases to apply a sufficient number of sprays, were among the factors responsible. As usual, the pest was particularly injurious to the crop of neglected trees and orchards.

The gray-banded leaf roller, *Argyrotaenia mariana,* Fern., was widespread and responsible for much of the loss of apples from insect injuries in the Annapolis Valley, N.S. Other species of leaf rollers were present in small numbers. The fruit tree leaf roller, *Archips argyrospila* Wlk., appeared to be on the increase locally in eastern Ontario but was reduced in numbers in the southern part of the province, and at its lowest level for several years in Norfolk County. It was also reduced in numbers in Quebec. The oblique-banded leaf roller, *Archips rosaceana* Harr., was locally injurious in the Okanagan Valley, B.C.

A marked decrease of the eye-spotted budmoth, *Spilonota ocellana* D. & S., was noted in the Martime Provinces. A disease of the larvae probably caused by a virus killed many of the larvae that overwintered in Nova Scotia and New Brunswick and, in the former province, parasites were recorded as numerous. Nevertheless, the species caused considerable injury to fruit. An increase of the budmoth occurred in Quebec and Ontario in orchards where special early sprays were not applied. The insect is a major pest in many orchards in the latter province.

Light infestations of the pear plant bug (green apple bug), *Lygus communis* Knight, the apple redbug, *Lygidea mendax* Reut., and the mullein leaf bug *Campylomma verbasci* Meyer, occurred locally in apple orchards in the Annapolis Valley, N.S., but caused little damage.

The apple sawfly, *Hoplocampa testudinea* Klug., has extended its range in southern Vancouver Island, B.C., and is now reported within four miles of Sidney. It was first found in 1940 in the Victoria district.

The roundheaded apple tree borer, *Saperda candida* Fab., was observed in a number of young orchards in Queens County, N.B., and was reported in comparatively large plantings of young apple trees in Ontario. It caused damage locally in Quebec.

Increased damage to plums by plum curculio, *Conotrachelus nenuphar* Hbst., was indicated in Ontario. Elsewhere the species was not particularly troublesome in 1943.

In general, aphids were not a serious pest in apple orchards during 1943. However, the apple aphid, *Aphis pomi* Deg., increased in southern Quebec, and occurred in outbreak form locally in different parts of Ontario, causing smutting of the fruit of certain varieties. In Nova Scotia, the rosy apple aphid, *Anuraphis roseus* Baker, was reduced by heavy mortality of overwintering eggs and unfavourable spring weather to a point where it was not sufficiently numerous to cause noticeable injury. The species was also negligible throughout Ontario.

The white apple leafhopper, *Typhlocyba pomaria* McAtee, was generally present in moderate numbers in apple-growing areas of Eastern Canada, but, except locally in southern Quebec, did not cause serious damage.

The mealy bug, *Phenacoccus sp.*, which was discovered in 1942 in apple orchards near Thornbury on the Georgian Bay, in Grey County, Ontario, has been found by Dr. Morrison, of the U.S. Bureau of Entomology and Plant Quarantine, to be specifically distinct from *P. aceris* Sig., which occurs on apple in Nova Scotia and British Columbia. Indications are that the Thornbury species may not become a commercially important apple pest.

In the Okanagan Valley, B.C., the European red mite, *Paratetranychus pilosus* C. & F., was numerous in early summer but largely disappeared by July. In Nova Scotia, the reverse was true, the mites being scarce early in the season and abundant towards autumn. Little damage occurred to fruit. In southern Ontario, the species caused conspicuous injury on apple, plum and peach.

The plum nursery mite, *Phyllocoptes fockeui* Nal. & Trt., continued to cause damage to plum nursery stock in the Niagara district, Ontario.

The pear slug, *Caliroa cerasi* L., was more abundant than usual in the Niagara district, Ontario, attacking pear, cherry, Japanese quince and, in one nursery, plum stock.

The green stinkbug, *Acrosternum hilare* Say, caused injury to maturing pears and peaches in the Niagara district, Ontario, and was occasionally found on plums. Damage to pears also occurred in Norfolk and Oxford Counties.

Infestation and damage of peach fruit by second and third generation larvae of the oriental fruit moth, *Grapholitha molesta* Busck, was the heaviest in years in the Niagara district, Ontario, in spite of the fact that 72 per cent of the second generation twig-infesting larvae were parasitized. Contributing factors were the greatly reduced crop on later varieties; weather conditions favourable to the insect and the concentration in healthy orchards of moths from trees killed or greatly weakened by the ususually severe winter and wet spring. The larvae were also found for the first time infesting sweet cherries but without effecting commercial damage.

Miscellaneous Insects

The outbreak of spruce budworm, *Archips fumiferana* Clem., in Ontario and western Quebec continues to be the most destructive insect infestation afflicting the forests of Eastern Canada, and has already caused the loss of millions of cords of balsam and white spruce. The budworm was also again very active in the Spruce Woods Forest Reserve, in Manitoba, and markedly increased in numbers in Douglas fir stands in several areas in southern British Columbia.

The allied form known as the jack pine budworm, at present referred to as *C. fumiferana,* has occurred in outbreak form for some years from north-central Saskatchewan (in the Fort a la Corne Provincial Forest) through Manitoba and northwestern Ontario eastward to about 100 miles beyond Lake Nipigon. With one or two local exceptions, the outbreak declined in intensity in 1943.

The Japanese beetle, *Popillia japonica* Newm., live specimens of which were first taken in Canada at Niagara Falls, Ont., in 1940, has since been trapped or otherwise collected at a number of points in southern and eastern Ontario and southern Quebec. The Ontario points include Windsor (1941), Riverside, Port Burwell, St. Thomas, Welland, Fort Erie, Queenston, Hamilton, Toronto, Brockville, Prescott (1942), and Brantford, London, Long Branch, Mimico, and Etobicoke Township (1943). In Quebec, a few specimens were taken at Dorval and Westmount in 1942, and at Montreal, Outremont, and Cantic, in 1943.

Mosquitoes, *Aedes* spp., were reported to be unusually abundant and troublesome to man and domestic animals in many areas over a large part of the Dominion during the spring and summer of 1943, as a result of plentiful precipitation. In some areas, blackflies (Simuliidae), too, were abundant.

Wasps, *Vespula* spp., were exceptionally numerous in the interior of British Columbia and, in addition to causing damage to fruits, interfered with haying and apple picking, and attacked sheep and sheep herders in the hills.

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